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August 15, 1968

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REPORT OF THE INTERIOR INTERAGENCY OIL SHALE TEST LEASE SITE SELECTION TASK FORCE

August 15, 1968

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Area 1a

I. GENERAL

A. Location and Access:

Area 1a is located about 24 miles southwest of Meeker, Colorado, and about 26 miles southeast of Rangely, Colorado. The Area is located 2 miles west of Piceance Creek. Ryan Gulch, a tributary of Piceance Creek, crosses the southeast corner of the Area. The Area is situated in Townships 1 and 2 South, Range 98 West, 6th P.M., Colorado, Rio Blanco County. The legal description of this Area is listed below, and outlined on overlay No. 1.

Township 1 South, Range 98 West

Section 34 - S½

Section 35 - S½

Section 36 - S½

Township 2 South, Range 98 West

Section 1 - Lots 5 thru 20.

Section 2 - Lots 5 thru 20.

Section 3 - Lots 2 thru 7, and 12; SW¼NE¼; S½NW¼; N½SW¼.

Section 10 - Lots 1 and 8.

Section 11 - N½; NE¼SE¼.

Section 12 - Lots 1 thru 6, and 10; SW¼NE¼; NE¼NW¼; S½NW¼; N½SW¼.

Area 1 contains a total of 3,404.00 acres, broken down as follows:

Public Domain - - - - - -	2,443.90
Patented Land With Oil Shale Reserved to the U. S. -	960.10
Patented Land With No Oil Shale Reservation -	None
Total -	3,404.00

Public access to the Area is gained from two roads. Ryan Gulch Road leaves the Piceance Creek Road in Section 33, Township 1 South, Range 97 West. Going southwest you enter the Area at the southeast corner of Section 1, Township 1 South, Range 98 West.

The other public access is also from the Piceance Creek Road, leaving it in Section 15, Township 1 South, Range 97 West. The road goes northwest about $2\frac{1}{4}$ miles, then turns southwest where it enters the Area in Section 35, Township 1 South, Range 98 West.

All roads leading from Piceance Creek are dirt, and there is no system of maintenance established. Piceance Creek Road is paved about 35 miles of its 50-mile length. (See Overlay No. 2 for locations of these public access roads.

Management of the public lands in Area 1a is by the White River Resource Area, Craig District, Bureau of Land Management. The Area is in the Yellow Creek Planning Unit, and all public domain lands have been classified for multiple-use management under the Act of September 19, 1964, (78 Stat. 986; 43 U.S.C. 1411-18), known as the Classification and Multiple Use Act, Public Law 88-607.

SITE 1b

I. General

A. Location and Access

Site 1b is located about 30 miles southwest of Meeker, Colorado, and about 18 miles southeast of Rangely, Colorado. It is about 9 miles west of Piceance Creek. Little Duck Creek flows through the north, and Box Elder Creek through the south of the area.

Site 1b is situated in Township 1 South, Range 99 West, 6th P.M., Colorado, Rio Blanco County. The legal description is shown below and outlined on Overlay No. 1.

Township 1 South, Range 99 West

Section 11 - Lots 7 thru 11; NE¼SE¼.

Section 12 - S½N½; S½.

Section 13 - All.

Section 14 - All.

Section 23 - N½; N½S½; SE¼SE¼.

Section 24 - N½; N½S½; S½SW¼; SW¼SE¼.

Section 25 - W½E½; W½.

Section 26 - E½E½.

The site contains a total of 3,780.15 acres, shown as follows:

Public Domain	2,900.15
Patented Land with Oil Shale Reserved to the U.S.	880.00
Patented Land with No Oil Shale Reservation	none
Total	3,780.15

Public access is available from three directions into the tract. However, public access means crossing Colorado Game, Fish and Parks land, and industrial and commercial traffic may not be permitted. These access routes are:

(a) Leave Piceance Creek Road in Section 33, Township 1 South, Range 97 West, traveling up Ryan Gulch through Area 1A, then crossing northwest into the Area.

(b) Leave Piceance Creek Road in Section 15, Township 1 South, Range 97 West, traveling northwest to Section 1, Township 1 South, Range 98 West. From there the Little Duck Creek Road leads into the north part of the Area, while the Box Elder Creek Road leads into the south of the Area.

(c) Leave the Piceance Creek Road in Section 22, Township 1 North, Range 97 West, traveling northwest on the Yellow Creek Road to Section 17, same Township. A road then goes south and west, where it comes into the Little Duck Creek and Box Elder Creek Roads. Routes into the Area are then as explained in (b) above.

All roads leading from Piceance Creek are dirt, and there is no maintenance system established. Piceance Creek Road is paved about 35 miles of its 50 mile length. (See Overlay No. 2 for locations of these public access routes.)

Management of the public lands in the Area is by the White River Resource Area, Craig District, Bureau of Land Management. The Area is in the Yellow Creek Planning Unit, and all public domain lands have been classified for multiple-use management under the Act of September 19, 1964 (78 Stat. 986; 43 U.S.C. 1411-18) known as The Classification and Multiple Use Act, Public Law 88-607.

Area ~~4~~ 1d

I. General

A. Location and Access

Area __is located about 26 miles southwest of Meeker, Colorado, and about 22 miles southeast of Rangely, Colorado. The Area is located nearly 1½ miles west of Piceance Creek. There aren't any major drainages running through the area.

Area 1d is located in Townships 1 North and 1 South, Range 98 West, 6th P.M., Colorado, Rio Blanco County. The legal description is listed below and outlined on overlay No. 1.

ownship
T/ 1 North., Range 98 West

Section 33 - Lots 1 thru 4; N½; N½S½.

Section 34 - Lots 1 thru 4; N½, N½S½.

ownship
T/ 1 South, Range 98 West

Section 3 - Lots 5 thru 8; S½N½, S½.

Section 4 - Lots 5 thru 8; S½N½, S½.

Area 1d contains 2,943.25 acres, ownership shown as follows:

Public Domain - 2,943.25

Patented land with oil shale reserved to the United States -

None

Patented Land with No Oil Shale Reservation - None

TOTAL - 2,943.25

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Here is only one public access route into the Area, and that is via the Pinto Gulch Road. Access adjoining the Piceance Creek road, where Pinto Gulch road takes off, is controlled by the Colorado Department of Game, Fish and Parks. Commercial and industrial traffic may not be permitted. The access route leaves Piceance Creek in Section 22, Township 1 North, Range 97 West; traveling northwest for 3 miles; then southwest to where the Pinto Gulch road crosses through the northwest corner of Section 33.

The Piceance Creek Road is paved for about 35 miles of the 50 mile length. Roads leading from Piceance Creek are dirt, and no maintenance system is established. (See Overlay No. 2 for location of this public access route.)

Management of the entire Area is by The White River Resource Area, Craig District, Bureau of Land Management. The Area is in the Yellow Creek Planning Unit, and all land has been classified for multiple use management under the Act of September 19, 1964 (78 Stat. 986; 43 U.S.C. 1411-18), known as the Classification and Multiple Use Act, Public Law 88-607.

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AREA ~~I~~ 2a

I. General

A. Location and Access

Area 2a is located about 19 miles southeast of Meeker, Colorado, and about 18 miles northwest of Rible, Colorado. It is 4 miles west of the unincorporated town of Rio Blanco. The northeast position of the Area corners on Piceance Creek. Numerous small drainages course through the Area, including Harrison Gulch, Story Gulch, and Schutte Gulch.

Area 2a is situated in Township 3 South, Range 95 West, 6th P.M., Colorado, Rio Blanco County. The legal description is listed below and outlined on Overlay No. 1.

Township 3 South, Range 95 West

Section 15 - SW$\frac{1}{4}$

Section 16 - ~~SW$\frac{1}{4}$~~ S$\frac{1}{2}$

Section 17 - ~~SW$\frac{1}{4}$~~ S$\frac{1}{2}$

Section 18 - Lots 3 & 4; E$\frac{1}{2}$SW$\frac{1}{4}$;SE$\frac{1}{4}$

Section 19 - Lots 1 through 4; NE$\frac{1}{4}$NE$\frac{1}{4}$, W$\frac{1}{2}$E$\frac{1}{2}$; E$\frac{1}{2}$W$\frac{1}{2}$; E$\frac{1}{2}$SE$\frac{1}{4}$

Section 20 - All

Section 21 - All

Section 22 - All

Section 23 - SW$\frac{1}{4}$

Township 3 South, Range 95 West (continued)

Section 26 - W½E½; W½
Section 27 - All
Section 28 - All
Section 29 - E½; W½NW¼;
SE¼NW¼; SW¼
Section 30 - Lots 1 through 4
E½W½; E½
Section 31 - Lots 1 through 4
E½W¼; E½
Section 32 - E½; W½NW¼; SE¼NW¼; SW¼
Section 33 - All
Section 34 - All
Section 35 - W½E½; W½

Area 2a contains a total of 9,808.04 acres, broken down as follows:

Public Domain	~~8,764.27~~	8,644.27
Patented land with oil shale reserved to the U.S.	~~843.01~~	963.01
Patented land with no oil shale reservation	200.76	
Total	9,808.04	

There is no public access into this Area from the Piceance Road. One indirect route into the Area may be across Colorado Game, Fish and Parks land. The State has purchased an easement in Section 1, Township 4 South, Range 95 West,

and another in Section 24, same township. The terms of the easement aren't known and it is very possible that public access is only for the purpose of hunting. This route leads south up Cow Creek, branching to the left, and joining the ridge road in about Section 35, Township 4 South, Range 95 West; then west on ridge road to Story Gulch; and south down Story Gulch to the Area.

All roads leading from Piceance Creek are dirt, and there is no maintenance system established. Piceance Creek road is paved about 35 miles of its 50-mile length. (See Overlay No. 2 for location of this possible access route.)

Management of the public lands in the Area is by the White River Resource Area, Craig District, Bureau of Land Management. The Area is in the Piceance Planning Unit, and all public domain lands have been classified for multiple use management under the Act of September 19, 1964 (78 Stat. 986; 43 U.S.C. 1411-18), known as the Classification and Multiple Use Act, Public Law 88-607.

SITE 2b

I. General

A. Location and Access

Site 2b is located about 21 miles southwest of Meeker; 22 miles northwest of Rifle; and 9 miles west of the unincorporated town of Rio Blanco. It lies adjacent to Piceance Creek on the north. Two forks of Stuart Gulch run through the site.

Site 2b is situated in Townships 3 and 4 South, Range 96 West, 6th P.M., Colorado, Rio Blanco County. The legal description is listed below and outlined on Overlay No. 1.

Township 3 South, Range 96 West

Section 10 - $S\frac{1}{2}NE\frac{1}{4}$; $SE\frac{1}{4}NW\frac{1}{4}$; $E\frac{1}{2}SW\frac{1}{4}$; $SE\frac{1}{4}$.

Section 11 - $S\frac{1}{2}NW\frac{1}{4}$; $SW\frac{1}{4}$; $W\frac{1}{2}SE\frac{1}{4}$.

Section 13 - $SE\frac{1}{4}NE\frac{1}{4}$; $W\frac{1}{2}NW\frac{1}{4}$; $SE\frac{1}{4}NW\frac{1}{4}$; $S\frac{1}{2}$.

Section 14 - All

Section 15 - $NE\frac{1}{4}$; $E\frac{1}{2}NW\frac{1}{4}$; $S\frac{1}{2}$.

Section 16 - $S\frac{1}{2}$.

Section 21 - All.

Section 22 - All.

Section 23 - All.

Section 24 - $N\frac{1}{2}NE\frac{1}{4}$; $SW\frac{1}{4}NE\frac{1}{4}$; $W\frac{1}{2}$; $SE\frac{1}{4}$.

Section 25 - $E\frac{1}{2}$; $W\frac{1}{2}NW\frac{1}{4}$; $SE\frac{1}{4}NW\frac{1}{4}$; $SW\frac{1}{4}$.

Section 26 - $E\frac{1}{2}$; $NW\frac{1}{4}$; $W\frac{1}{2}SW\frac{1}{4}$.

Section 27 - All.

Section 28 - E½.

Section 33 - E½.

Section 34 - All.

Section 35 - All.

Section 36 - All.

Township 4 South, Range 96 West

Section 1 - Lots 3 and 4; S½NW¼; S½.

Section 2 - Lots 1 thru 4; S½N½; S½.

Section 3 - Lots 1 thru 4; S½N½; S½.

Section 4 - Lots 1 and 2; S½NE¼, SE¼.

Site 2b contains a total of 11,641.76 acres, shown as follows:

Public Domain	9,281.67
Patented Land with Oil Shale Reserved to the U.S.	1,840.00
Patented Land with No oil Shale Reservation	520.09
Total	11,641.76

No public access is available into this area. All routes are blocked by privately owned land, either along Piceance Creek or in the headwaters of drainages that lead down into here.

All roads leading from Piceance Creek are dirt, and no system of maintenance is established. Piceance Creek Road is paved for about 35 miles of its 50 mile length.

Management of the public lands in the Area is by the White River Resource Area, Craig District, Bureau of Land Management. The Area is in the Piceance Planning Unit, and all public domain lands have been classified for multiple use management under the Act of September 19, 1967 (78 Stat. 986; 43 U.S.C. 1411-18), known as The Classification and Multiple Use Act, Public Law 88-607.

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AREA ~~III~~ 2c

I. General

A. Location and Access

Area 2c is located about 24 miles southwest of Meeker; 22 miles northwest of Rifle; and 9 miles west of the unincorporated town of Rio Blanco. It lies about eight miles south of Piceance Creek. Willow Creek and the West Fork of Stuart Gulch are the major sub-drainages running through the area.

Area 2c is situated in Township 4 South, Range 98 West, Sixth Principal Meridian, Colorado, Rio Blanco County. The legal description follows, and is outlined on Overlay No. 1 .

Township 4 South, Range 96 West

Section 1 - Lots 1 through 4; S½N½; S½

Section 2 - Lots 1 through 4; S½N½; S½

Section 3 - Lots 1 through 4; S½N½; S½

Section 4 - Lots 1 through 4; S½N½; S½

Section 5 - Lots 1 through 4; S½N½; S½

Section 8 - All

Section 9 - All

Section 10 - All

Section 11 - All

Section 12 - All

Section 13 - All

Section 14 - All

Section 15 - All

Section 16 - E½NE¼; NW¼NE¼; W½; SE¼

Section 17 - E½; NW¼; W½SW¼; SE¼SW¼

Area 2c contains ~~9,522.88~~ 9,522.98 acres, broken down as follows:

Public Domain	~~8,122.11~~	8,122.21
Patented Land With Oil Shale Reserved To the U. S.	1,240.52	
Patented Land With No Oil Shale Reservation	160.25	
TOTAL	~~9,522.88~~	9,522.98

No public access is available into Area 2c. All routes are blocked by privately owned land, either along Piceance Creek, or in the major drainages leading into the area. Colorado Department of Game, Fish and Parks has applied to BLM for a right-of-way that could be used to enter the area from the west. This route would come from Piceance Creek up Black Sulphur to the ridge west of Hunter Creek; then east.

All roads leading from Piceance Creek are dirt, and maintenance system is established. Piceance Creek Road is paved for about 35

miles of the 50-mile length.

Management of the public lands in the Area are from the White River Resource Area, Craig District, Bureau of Land Management. The Area is in the Piceance Planning Unit, and all public domain lands have been classified for multiple-use management under the Act of September 19, 1964 (78 Stat. 986; 43 U.S.C. 1411-18), known as the Classification and Multiple Use Act, Public Law 88-607.

SITE 3a

I. General

A. Location and Access

Site 3a is located about 29 miles west of Meeker, Colorado, and about 13 miles east of Rangely, Colorado. It is about 6 miles west of Yellow Creek and 7 miles south of the White River. Greasewood Gulch runs approximately through the center of the area, while tributaries to Barcus Gulch also enter the area.

Site 3a is located in Township 1 North, Ranges 99 and 100 West, 6th P.M., Colorado, Rio Blanco County. The legal description follows and is outlined on Overlay No. 1.

Township 1 North, Range 99 West

Section 3 - Lots 3 and 4; SW¼NE¼; S½NW¼; SW¼.
Section 4 - Lots 1 thru 4; S½N½; S½.
Section 5 - Lots 1 thru 4; S½N½; S½.
Section 6 - Lots 1 thru 3, and 8 thru 11; S½NE¼; SE¼NW¼; E½SW¼; SE¼.
Section 8 - NW¼; NE¼
Section 9 - All.
Section 10 - W½.
Section 15 - W½.
Section 16 - All.

Section 17 - All.

~~Section 18 - NE¼.~~

Section 21 - All.

Section 22 - W½.

Section 27 - W½.

Section 28 - All.

Section 33 - Lots 1 thru 4; N½; N½S½.

Section 34 - NW¼; N½SW¼.

Township 1 North, Range 100 West

Section 1 - Lots 1 thru 4; S½N½; S½.

Section 11 - SE¼.

Section 12 - All.

Section 13 - E½E½.

Section 24 - E½NE¼.

This site contains a total of 9,586.48 acres, shown as follows:

Public Domain	7,462.92
Patented Land with Oil Shale Reserved to the U.S.	2,123.56
Patented Land with No Oil Shale Reservation	none
Total	9,586.48

Public access is available from only one direction. Leave the Piceance Creek road in Section 15, T.1N., R.97W., and travel northwest up the Yellow Creek road to Barcus Gulch; then southwest to North Barcus (not labeled as such on the map) in Section 8, T.1N., R. 98W,; then west and southwest into the Area.

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SITE 3a

The Calamity Ridge Access Road is now under construction by the Bureau of Land Management. It is being built in segments, and the fiscal year portion for 1969 will enter site 3a from the west at about Section 19, T. 1 N., R. 99 W., and then into Sections 20 and 21. Contract for this part will be let this fall. Projected construction route for FY 1970 puts the road down Greasewood Gulch and onto State Highway 64. This road, when finished, will provide public access into site 3a from two directions, forming a loop road. At the present time about 7 miles of the road is completed, beginning at the highway and going north into Section 8 , T. 1 N., R. 100 W.

All roads leading from Piceance Creek are dirt, and there is no maintenance system established. Piceance Creek road is paved about 35 miles of its 50-mile length. (See Overlay No. 2 for location of this public access route.)

Management of the public lands in the Area is by the White River Resource Area, Craig District, Bureau of Land Management. The Area is in the Yellow Creek Planning Unit, and all public domain lands have been classified for multiple use management under the Act of September 19, 1964 (78 Stat. 986; 43 U.S.C. 1411-18), known as the Classification and Multiple Use Act, Public Law 88-607.

B. Topography

Topography for all sites is generally the same. The following paragraph, taken from "Water and Related Land Resources, White River Basin in Colorado," best describes the locale.

> "West of Meeker ... an area of diverse topography including dissected lesser plateaus, sharp ridges, abrupt cliffs, and rugged badlands interspersed with open valleys, parks, and basins. The presence of underlying rock layers with wide differences in resistance to erosion has been the principal factor in development of these features. Differential erosion has resulted in the more resistant rock layers standing in relief while broad open valleys have been cut in the softer rocks."

Elevations range from 6,300 feet to 8,300 feet.

C. Climate:

There are no meterological stations in the Area; the nearest stations being at Meeker and Rangely. Information for both stations is shown below.

Mean Precipitation

Year	Meeker	Rangely	Year	Meeker	Rangely
1967	18.92	Not Available	1962	13.60	6.52
1966	13.20	7.83	1961	20.02	10.51
1965	18.28	13.86	1960	17.70	7.73
1964	18.69	8.79	1959	16.92	6.91
1963	13.90	7.59	1958	13.88	3.76

Annual average for last ten years:

Meeker - 16.91

Rangely - 8.16

Annual precipitation in the Piceance Basin varies from approximately 12 inches in the extreme northwest corner to approximately 24 inches in the southwest corner.

Seasonal distribution of precipitation is variable but generally remains constant from year to year. Slightly less than half of the precipitation occurs during the months of December to April as snow. The spring of the year usually has only small amounts of precipitation. During the latter part of the summer, thunderstorms occur generally throughout the Area. Intensity of these storms can vary from day to day from very light to very severe. Fall weather can vary from rains to infrequent snow storms.

Temperatures in the Area range in extremes. In the past 5 years, BLM personnel have noted summer temperatures of up to 100° and winter temperatures to a -40°. Usually July is the hottest month with December and January being the coldest. Temperatures will vary considerably as elevation increases. The upper elevations are cooler in the summer and colder in the winter than the lower elevations. Annual average maximum, minimum and mean temperatures of Meeker and Rangely are as follows:

MEEKER:

	Temperature			Precipitation
Year	Maximum	Minimum	Average	Total
1958	67.3	21.3	45.8	13.88
1959	65.9	24.1	44.9	16.92
1960	67.6	21.7	44.3	17.70
1961	65.2	21.3	43.1	20.02
1962	65.8	15.2	44.5	13.60
1963	69.2	15.8	46.0	13.90
1964	69.4	18.5	42.5	18.69
1965	65.8	24.8	43.7	18.28
1966	69.6	19.8	44.7	13.20
1967	67.1	19.8	44.6	18.92

RANGELY:

	Temperature			Precipitation
Year	Maximum	Minimum	Average	Total
1958	72.6	20.0	47.3	3.76
1959	72.7	23.2	*46.7 Est.	6.91
1960	73.1	13.5	44.8	7.73
1961	73.5	17.4	45.9	10.51
1962	71.5	10.2	46.2	6.52
1963	73.7	12.4	48.1	7.59
1964	75.4	17.4	*43.6 Est.	8.79
1965	70.7	17.7	*43.6 Est.	13.86
1966	73.9	13.4	45.4	7.83
1967	- Information not available.			

* Estimated totals due to insufficient data.

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Evaporation rates vary between 34 and 35 inches and are generally uniform over the Area.

There is a difference in humidity due to elevation, but generally the Area is semi-arid on the northern portion and somewhat less on the southern portion, where more precipitation is available.

Snow occurs over the entire Area and usually starts in October. The lower elevations usually melt the first snows, but by the middle of November snow will begin to remain on the ground. Snow depth will vary from less than 1 foot to 3 feet at the lower elevations to between 2 and 6 feet at the higher elevations.

Generally wind is no problem. Observations in the last five years by BLM personnel indicate that early spring strong winds will blow for about a month during March-April periods. In the summer locally strong winds occur with thunderstorms. In the fall winds occur for one to three days at a time as snow storms begin moving into the Area. Usually winds prevail from the north and west. On occasion winds are very strong but cause only minor property damage.

Frost free season varies from 124 days at the lower elevations to 50 days at the upper elevation. Generally the only crops grown are native and irrigated hay, corn for silage, and some small grains, and they are grown along Piceance Creek, Yellow Creek and White River somewhat distant from this Area.

Climate has a limiting effect within all areas. The upper elevations are used more during the summer by cattle and deer. The lower elevations are used by cattle, deer and sheep.

Site 1a

D. Cadastral Survey:

Both exterior and interior boundaries of this Area were surveyed in 1938, using brass-cap markers. However, only two corner monuments have been found by BLM personnel:

SE Section Corner, S1, T. 2 S., R. 98 W.

NW Section Corner, S2, T. 2 S., R. 98 W.

(See Overlay No. 2 for location of these found survey corners.)

Site 1b

D. Cadastral Survey

Portions of the exterior and interior boundaries of this Township were surveyed in 1883, 1884, 1904, 1933, and 1938. BLM people, in their field work haven't found any of these corners.

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Site 1d

D. Cadastral Survey

Parts of the exterior and interior boundaries of these townships were surveyed in 1883, 1904, 1907 and 1938. BLM field people have found the following four corners within the Area:

NW Section Corner, Section 34, T. 1 N., R. 98 W.

W¼ corner, Section 33, T. 1 N., R. 98 W.

SE Section Corner, Section 3, T. 1 S., R. 98 W.

SW Section Corner, Section 4, T. 1 S., R. 98 W.

(See Overlay No. 2 for location of these found corners.)

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Site 2a

D. Cadastral Survey

The exterior and interior boundaries of this Township were surveyed in 1888. Only one corner has been found by BLM field people: S¼ Corner, Section 33, T3S, R95W. (See Overlay No. 2 for location of the found corner.)

Site 2b

D. Cadastral Survey

Parts of the exterior boundary of the Township were surveyed in 1888, 1938 and 1953; the interior surveyed in 1888. Only three corners have been found by BLM field personnel:

SE Section Corner, Section 21, T. 3 S., R. 96 W.
SW Section Corner, Section 2, T. 4 S., R.96 W.
SW Section Corner, Section 3, T. 4 S., R. 96 W.

(See Overlay No. 2 for location of these corners.)

Site 2c

D. Cadastral survey

Parts of the exterior boundary of the Township were surveyed in 1888, 1914, 1938, and 1953; the interior surveyed in 1888 and 1953. Bureau employees have been able to locate the following nine corners on the ground during their field work.

NW Section Corner, Section 1, T4S, R97W.
SE Section Corner, Section 1, T4S, R97W.
E Quarter Corner, Section 1, T4S, R97W.
S Quarter Corner, Section 2, T4S, R97W.
SW Section Corner, Section 4, T4S, R97W.
SE Section Corner, Section 11, T4S, R97W.
SW Section Corner, Section 14, T4S, R97W.
S Quarter Corner, Section 15, T4S, R97W.

(See Overlay No. 2 for the location of these found corners.)

Site 3a

D. Cadastral Survey

Parts of the exterior and interior boundaries of these Townships were surveyed in 1883 and 1904. Only four survey corners have been found by BLM personnel.

SW Section Corner, Section 2, T. 1 N., R. 99 W.

NE Section Corner, Section 6, T. 1 N., R. 99 W.

SE Section Corner, Section 8, T. 1 N., R. 99 W.

SE Section Corner, Section 12, T. 1 N., R. 100 W.

(See Overlay No. 2 for location of these found corners.)

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Site 1a:

E. Economic Situation:

There are no towns or cities in Area 1a. Seven families engaged in the livestock business receive all or part of their income from this Area. Many families also receive income in part or entirely from oil exploration activities, principally from being partially bought out by oil firms.

Rangely and Meeker are the nearest towns to the Area. According to the 1969 census the population of Rangely was 1,464 and the population of Meeker was 1,655. There is no indication of any substantial increase in population in the immediate future. With the development of oil shale work and/or Project Bronco, an increase in the number of people in both towns and an increase in the number of families living near the Area are expected to occur.

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Site 1b

E. Economic Situation

There are no towns or cities in Area 1b. Nine families engaged in the livestock business receive all or part of their income from this Area. Many families also receive income in part or entirely from oil exploration activities, principally from being bought out by the oil companies.

Rangely and Meeker are the nearest towns and according to the 1960 census the population of Rangely was 1,464 and the population of Meeker was 1,655. There is no indication of any increase in population in the immediate future. With the development of oil shale work and/or Project Bronco, an increase in the number of people in both towns and an increase in the number of families living near the Area is expected to occur.

Site 1d

E. Economic Situation

There are no towns or cities in the Area. Only one family engaged in the livestock business receive all or part of its income from the Area. This family also receives income from oil exploration activities, particularly from being bought out by an oil company.

Rangely and Meeker are nearest towns and according to the 1960 census the population of Rangely was 1464 and the population was 1655. There is no indication of any substantial increase in population in the immediate future. With the development of oil shale work and/or Project Bronco, an increase in the number of people in both towns and an increase in the number of families filing near the Area in the Planning Unit is expected to occur.

Site 2a

E. Economic Situation

There are no towns or cities in Area 2a. Ten families engaged in the livestock business receive all or part of their income from this Area. Many families also receive income in part or entirely from oil exploration activities, principally from being bought out by the oil companies.

Rifle and Meeker are the nearest towns and, according to the 1960 census the population of Rifle was 2,135 and the population of Meeker was 1,655. There is no indication of any substantial increase in population in the immediate future. With the development of oil shale work and/or Project Bronco, an increase in the number of people in both towns and an increase in the number of families living near the Area is expected to occur.

Site 2b

E. Economic Situation

There are no towns or cities in the Area. Fourteen families engage in the livestock business receive all or part of their income from this Area. Many families also receive income in part or entirely from oil exploration activities, principally from being bought out by the oil firms.

Rifle and Meeker are the nearest towns, and according to the 1960 census the population of Rifle was 2135 and the population of Meeker was 1655. There is no indication of any substantial increase in population in the immediate future. With the development of oil shale work an increase in the number of people in both towns, and an increase in the number of families living near the Area is expected to occur.

Site 2c

E. Economic Situation

There are no towns or cities in the Area. Twelve families engaged in the livestock business receive all or part of their income from this Area. Many families also receive income in part or entirely from oil exploration activities, primarily from being bought out by the oil companies.

Rifle and Meeker are the nearest towns and according to the 1960 census the population of Rifle was 2,135 and the population of Meeker was 1,655. There is no indication of any substantial increase in population in the immediate future. With the development of oil shale work, an increase in the number of people in both towns and an increase in the number of families living near the Area is expected to occur.

Site 3a

E. Economic Situation

There are no towns or cities in the Area. Five families engaged in the livestock business receive all or part of their income from this Area. Many families also receive income in part or entirely from oil exploration activities, principally from being bought out by the oil firms.

Rangely and Meeker are the nearest towns to the Area, and according to the 1960 census, the population of Rangely was 1464 and the population of Meeker was 1655. There is no indication of any substantial increase in population in the immediate future. With the development of oil shale work and/or Project Bronco, an increase in the number of people in both towns and an increase in the number of families living near the Area is expected to occur.

F. Land Use Demands:

Until the advent of frenzied oil shale interest in the past few years, this Area was stable in its land uses. Livestock grazing (cattle) has dominated use since the early 1880's. Ranchers were stable operators, combining use of their patented ground with Bureau of Land Management grazing permits into an economic ranching unit.

However, the high value placed upon oil shale ground by major oil companies has caused ownership changes. But ranching goes on as usual. The four livestock operators in this Area have been almost completely bought out by oil firms. The procedure has been to pay the rancher a huge sum for his land title and water rights. Not ready to develop the oil shale yet, the firm has leased back the land and water rights to the rancher for a nominal fee - usually just for taxes. When the oil company needs the land for development the rancher will relinquish the land and water.

The only other public use of the area is for deer hunting. Public access, which is somewhat restricted in the Piceance basin, makes this a desirable big game hunting area. (See Piceance Basin access study done by James Munger.)

The land is valuable for other purposes besides the three mentioned above (livestock grazing, oil shale development, big game hunting):

Habitat for small game - rabbits, sage grouse, chukar partridge; and predators, mainly coyotes, and often bobcats.

Eagles, hawks and magpies also use the area.

Watershed for retention, storage, flood prevention, water quality control.

Open space, free from man-made pollution of the air and the environment.

No demands have yet been made on any site locations for urban or industrial uses.

G. Planning and Land Use Controls:

Rio Blanco County has recently adopted a county-wide zoning resolution. The resolution (quoting from the source) establishes "zoning districts ..... regulating: The use of buildings, structures, and land for trade, industry, residence, recreation, public and other purposes; the location, height, bulk, and size of buildings and other structures; the lot size; the size of yards, courts, and other open spaces; the density and distribution of population; and providing further a description of .... penalties to be prescribed for the violation of these provisions, ... and methods of administration and enforcement to be applied."

The resolution is new and has yet to be tested in local court.

The County has also adopted subdivision regulations and mobile home regulations.

However, the County has no overall comprehensive county plan. Local officials feel the land use controls they have in effect serve them as a plan.

Any mining activity in the Area must follow and abide by the land use controls established by the County.

The Colorado State Planning Office has contracted with Farmers Home Administration, U. S. Dept. of Agriculture, to do a broad-based county-wide plan. This is so that counties and communities will be able to qualify for FHA sewer and water grants. Rio Blanco County will be done, but the date isn't known.

COLORADO LAND USE CONTROL STATUS

Table #1

1. Rio Blanco (County)

2. — (City or Town)

3. Classification: County
4. Population: 5,450 (1965 est)
5. Form of Government: County commissioners

PLANNING

6. Plan Commission/Office - Date: Commission ; no professional staff
7. Plan in Effect - Date:
8. Plan Pending: Expected in 1967
9. Type of Plan:
10. Scope of Plan:
11. Plan Assistance:
12. Who Wrote Plan: Jim Swell, Consultant
13.

ZONING

14. Zoning Authority: 15. Date:
16. Zoning in Effect/Date:
17. Type of Zoning:
18. Zoning Follows Planning:
19.

OTHER CONTROLS, CODES & ORDINANCES

20. Official Map: 21. Building Code:
22. Housing Code: 23. Subdivision Regs:
24. Sign Control: 25. Dumps, junkyards:
26. Other:

27. BLM District: CRAIG
28. Resource Area/Planning Unit: – See attached Sheet –
29. BLM Acreage & % of Total: 1,217,762 – 58.3%

30. Local Contacts for Planning & Zoning: Frank Cooley, County Atty (878-5065); Iver M. Villa, Meeker 81641 (878-4417) Chmn Plan Comm.

31. Remarks:

12/18/67 (Date)

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COLORADO LAND USE CONTROL STATUS

Table #2

1. Rio Blanco (County)

2. Meeker (City or Town)

3. Classification: County seat; town

4. Population: 1,655 (1965 est)

5. Form of Government: Mayor-council

PLANNING

6. Plan Commission/Office - Date: Commission 1964

7. Plan in Effect - Date:

8. Plan Pending: In conjunction with County plan.

9. Type of Plan:

10. Scope of Plan:

11. Plan Assistance:

12. Who Wrote Plan:

13.

ZONING

14. Zoning Authority:

15. Date:

16. Zoning in Effect/Date:

17. Type of Zoning:

18. Zoning Follows Planning:

19.

OTHER CONTROLS, CODES & ORDINANCES

20. Official Map:

21. Building Code:

22. Housing Code:

23. Subdivision Regs:

24. Sign Control:

25. Dumps, junkyards:

26. Other:

27. BLM District: CRAIG

28. Resource Area/Planning Unit: WHITE RIVER RA (Strawberry PU 01-33)

29. BLM Acreage & % of Total: —

30. Local Contacts for Planning & Zoning: Joseph B. Sullivan, 969-6th, Meeker 81641, Chrm Plan Comm.

31. Remarks: Town Hall (878-5591)

12/18/67
(Date)

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COLORADO LAND USE CONTROL STATUS

Table #3

1. RIO BLANCO (County)

2. RANGELY (City or Town)

3. Classification: Town
4. Population: 1,850 (1963 est)
5. Form of Government: Mayor - city Mgr - council

PLANNING

6. Plan Commission/Office - Date: Commission 1955; no professional staff
7. Plan in Effect - Date: yes
8. Plan Pending:
9. Type of Plan: "701"
10. Scope of Plan:
11. Plan Assistance:
12. Who Wrote Plan:
13. Town has public improvements plan.

ZONING

14. Zoning Authority: yes
15. Date:
16. Zoning in Effect/Date: yes 1956
17. Type of Zoning:
18. Zoning Follows Planning:
19.

OTHER CONTROLS, CODES & ORDINANCES

20. Official Map:
21. Building Code: yes
22. Housing Code:
23. Subdivision Regs:
24. Sign Control:
25. Dumps, junkyards:
26. Other: Plumbing & electrical codes

27. BLM District: CRAIG
28. Resource Area/Planning Unit: WHITE RIVER RA (Douglas Creek PU 01-08)
29. BLM Acreage & % of Total: —

30. Local Contacts for Planning & Zoning:

31. Remarks: Town Clerk (675-8611)

12/18/67
(Date)

FOR U. S. GOVERNMENT USE ONLY

COLORADO LAND USE CONTROL STATUS

Table #4

1. GARFIELD (County)

2. — (City or Town)

3. Classification: County
4. Population: 12,600 (1965 est)
5. Form of Government: County commissioners

PLANNING

6. Plan Commission/Office - Date: Commission ; no professional staff
7. Plan in Effect - Date:
8. Plan Pending: Plan is nearing final stages.
9. Type of Plan:
10. Scope of Plan:
11. Plan Assistance:
12. Who Wrote Plan: Terry Brown (Ken R. White Co.) is writing the plan.
13.

ZONING

14. Zoning Authority:
15. Date:
16. Zoning in Effect/Date:
17. Type of Zoning:
18. Zoning Follows Planning:
19. Zoning is pending

OTHER CONTROLS, CODES & ORDINANCES

20. Official Map:
21. Building Code:
22. Housing Code:
23. Subdivision Regs:
24. Sign Control:
25. Dumps, junkyards:
26. Other:

27. BLM District: Glenwood Springs; Craig; Grand Junction
28. Resource Area/Planning Unit: — See attached Sheet —
29. BLM Acreage & % of Total: 658,208 - 34.3%

30. Local Contacts for Planning & Zoning: Pete Mattivi, New Castle 81647 (984-2366), Chmn, Plan Comm.

31. Remarks:

12/11/67
(Date)

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COLORADO LAND USE CONTROL STATUS

Table #5

1. GARFIELD (County)

2. RIFLE (City or Town)

3. **Classification:** Home rule city
4. **Population:** 2,200 (1965 est)
5. **Form of Government:** Mayor-city mgr-council

PLANNING

6. **Plan Commission/Office - Date:** Commission 1950; no professional staff
7. **Plan in Effect - Date:**
8. **Plan Pending:**
9. **Type of Plan:**
10. **Scope of Plan:**
11. **Plan Assistance:**
12. **Who Wrote Plan:**
13.

ZONING

14. **Zoning Authority:** yes
15. **Date:**
16. **Zoning in Effect/Date:** yes 1950 (revised 1964)
17. **Type of Zoning:**
18. **Zoning Follows Planning:**
19.

OTHER CONTROLS, CODES & ORDINANCES

20. **Official Map:**
21. **Building Code:** yes
22. **Housing Code:**
23. **Subdivision Regs:** yes 1964
24. **Sign Control:**
25. **Dumps, junkyards:**
26. **Other:** Electrical code

27. **BLM District:** Grand Junction
28. **Resource Area/Planning Unit:** Garfield RA (Grand Hogback PU 07-01; Cliff PU 07-03)
29. **BLM Acreage & % of Total:** —

30. **Local Contacts for Planning & Zoning:** Frank T. Temple, 218 Ash Ave, Rifle 81650 (625-2021)

31. **Remarks:** Info: City clerk (625-2121)

12/11/67
(Date)

II. STATUS FACTORS

Appendix I, Status Map of Central Piceance Creek Area, shows the status of the land including and surrounding the proposed lease sites in Colorado. Pre-1920 oil shale claims excluded consideration of a suitable lease site in Utah.

The legend of the map of Appendix I shows the markings for the areas in the Piceance Creek area for

(1) the area where the land is patented without mineral reservation,

(2) the area where the surface is patented but where the oil shale and, in some cases, other minerals are reserved,

(3) the area under application for sodium leases, and

(4) the areas within the proposed lease sites covered by recent mining claims.

The legend also shows the delineation of the proposed lease areas and the area of pre-1920 oil shale claims.

It can be noted that area 3-a is substantially free of recent mining claims but that the other six areas are more or less covered by mining claims. Area 1-b is entirely covered by recent mining claims while area 2-b is about 50% free of recent mining claims.

In some cases, land where the surface has been patented but the oil shale retained by the United States has been covered by recent mining claims. In other cases such land is free of recent mining claims.

Appendix II is land office plats showing the complete land office status for the proposed lease areas. The plats are master title plats, oil and gas plats and sodium-potassium plats including supplemental plats. Included are overlays showing the location and names of recent mining claims.

STATUS OF FEE LAND

SITE 1a

T. 1 S., R. 98 W., S. 34 - S½ - 320 acres - Surface patented to Nellie M. Reagle with option to Humble Oil Co. Oil shale reserved to the U.S.

T. 2 S., R. 98 W., S. 3, Lots 2, 3, 4; SW¼NE¼; S½NW¼; N½SW¼ - 320.10 acres - Surface patented to Nellie M. Reagle with option to Humble Oil Co. Oil shale reserved to the U.S.

STATUS OF FEE LAND

SITE 1b

T. 1 S., R. 99 W., S. 11 - NE¼SE¼ - 40 acres - Surface patented to Colorado Dept. of Game, Fish and Parks. Oil shale reserved to the U.S./

S. 12 - S½N½; S½SW¼ - 240 acres - Surface patented to Colorado Dept. of Game, Fish and Parks. Minerals reserved to the U.S.

S. 23 - SE¼SE¼ - 40 acres - Surface patented to Colorado Dept. of Game Fish and Parks. Oil shale reserved to the U.S.

S. 24 - S½SW¼; SW¼SE¼ - 120 acres - Surface patented to Colorado Dept. of Game, Fish and Parks. Oil shale reserved to the U.S.

S. 25 - W½E½; E½W½; W½NW¼ - 400 acres - Surface patented to the Colorado Dept. of Game, Fish and Parks. Oil shale reserved to the U.S.

S. 26 - NE¼NE¼ - 40 acres.- Surface patented to Colorado Dept. of Game, Fish and Parks. Oil shale reserved to the U.S.

STATUS OF FEE LAND

SITE 1d

There is no patented land in Site 1d.

STATUS OF FEE LAND

SITE 2a

T. 3 S., R. 95 W., S. 15 - NE¼SW¼ - 40 acres - Surface and minerals patented to Joe Robinson.

S. 16 - NW¼SE¼ - 40 acres Surface patented to Joe Robinson. Oil shale reserved to the U.S.

S. 18 - Lots 3 & 4 - 80.76 acres - Surface and minerals patented to Weiland Ranch and Mercantile Co.

S. 19 - Lots 1 thru 4; SE¼NW¼ - 202.32 acres - Surface patented to Weiland Ranch and Mercantile Co. Oil shale reserved to the U.S.

S. 20 - W½SW¼ - 80 acres - Surface patented to Weiland Ranch and Mercantile Co. Oil shale reserved to the U.S.

S. 22 - NE¼NE¼ - 40 acres - Surface and minerals patented to Joe Robinson.

S. 23 - NE¼SW¼ - 40 acres - Surface patented to E. Clark Jones. Oil shale reserved to the U.S.

S. 29 - W½NW¼; SE¼NW¼; SW¼ - 280 acres - Surface patented to Weiland Ranch and Mercantile Co. Oil shale reserved to the U.S.

Site 2a continued

S. 30 - Lot 1; NE¼NW¼ - 80.69 acres - Surface patented to Weiland Rnach and Mercantile Co. Oil shale reserved to the U.S.

S. 32 - W½W½ - 160 acres - Surface patented to Weiland Ranch and Mercantile Co. Oil shale reserved to the U.S.

STATUS OF FEE LAND

SITE 2b

T. 3 S., R. 96 W., S. 13 - SE¼NE¼ - 40 acres - Surface and minerals patented to Humble Oil Co.

S. 14 - W½NE¼ - 80 acres - Surface patented to G. Oldlands with option to Humble Oil Co. Oil shale reserved to the U.S.

S. 15 - SW¼NW¼; NE¼SW¼; W½SE¼ - 160 acres - Surface patented to G. Oldlands with option to Humble Oil Co. Oil shale reserved to the U.S.

S. 16 - E½SW¼ - 80 acres - Surface patented to G. Oldlands with option to Humble Oil Co. Oil shale reserved to the U.S.

S. 21 - N½NE¼ - 80 acres - Surface patented to Reuben & Norma Oldlands. Oil shale reserved to the U.S.

- E½NW¼; SE¼SW¼; W½SE¼ - 200 acres - Surface patented to Reuben and Norma Oldlands with option to Humble Oil Co. Oil shale reserved to the U.S.

S. 22 - W½NW¼; N½SW¼; SE¼SW¼ - 200 acres - Surface patented to Reuben & Norma Oldlands. Oil shale reserved to the US.

S. 24.- E½E½ - 160 acres - Surface patented to Weiland Ranch & Mercantile Co. Oil shale reserved to the U.S.

Site 2b continued

S. 25 - NE¼NE¼ - 40 acres - Surface patented to Weiland Ranch & Mercantile Co. Oil shale reserved to U.S.

S. 26 - W½SW¼ - 80 acres - Surface and minerals patented to Reuben & Norma Oldlands with option to TOSCO, 11/15 interest, and SOHIO, 4/15 interest.

- SE¼SW¼; S½SE¼; - 80 acres-Surface patented to Reuben & Norma Oldlands with option to Humble Oil Co. Oil shale reserved to the U.S.

S. 27 - NW¼; N½SW¼ - 240 acres - Surface patented to Reuben & Norma Oldlands. Oil shale reserved to U.S.

S. 28 - NE¼SE¼ - 40 acres - Surface patented to Reuben & Norma Oldlands. Oil shale reserved to U.S.

- W½NE¼ - 80 acres - Surface patented to Reuben & Norma Oldlands with option to Humble Oil Co. Oil shale reserved to U.S.

S. 33 - W½NE¼ - 80 acres - Surface patented to Reuben & Norma Oldlands with option to Humble Oil Co. Oil shale reserved to U.S.

S. 35 - NE¼; NW¼SE¼ - 200 acres - Surface patented to Reuben & Norma Oldlands iwth option to Humble Oil Co! Oil shale reserved to U.S.

SITE 2b continued

T. 4 S., R. 96 W., S. 2 - W½SW¼ - 80 acres - Surface patented to H. G. Berthelson. Oil shale is reserved to the U.S.

S. 4 - Lot 1 - 40.09 acres - Both the surface and minerals are patented to TOSCO, 11/15 interest, and SOHIO, 4/15 interest.

STATUS OF FEE LAND

SITE 2c

T. 4 S., R. 97 W., S. 1 - SE¼NE¼; SE¼SW¼; N½SE¼; SW¼SE¼ - 200 acres - Surface patented to Reuben & Norma Oldlands, 1/2 interest, and Walter Oldlands estate, 1/2 interest. Oil shale is reserved to the U.S.

S. 2 - Lots 1 & 2; SW¼NE¼; NW¼SE¼ - 160.52 acres - Surface is patented to H. G. Berthelson. Oil shale is reserved to the U.S.

S. 4 - Lot 1; S½NE¼; NW¼SE¼ - 160.25 acres - Both surface and minerals are patented to Humble Oil Co.

S. 12 - NE¼; SE¼NW¼; NE¼SW¼; S½SW¼; N½SE¼ - 400 acres - Surface is patented to Reuben & Norma Oldlands. 1/2 interest, and Walter Oldlands estate, 1/2 interest. Oil shale is reserved to the U.S.

S. 13 - W½NW¼ - 80 acres - Surface is patented to Reuben & Norma Oldlands, 1/2 interest, and Walter Oldlands estate, 1/2 interest. Oil shale is reserved to the U.S.

S. 14 - NE¼NE¼; S½NE¼; SE¼SW¼; SE¼ - 320 acres - Surface is patented to Reuben & Norma Oldlands, 1/2 interest, and Walter Oldlands estate, 1/2 interest. Oil shale is reserved to the U.S.

S. 16 - W½SE¼ - 80 acres - Surface is patented to Ira C. Johnson. Oil shale is reserved to the U.S.

STATUS OF FEE LAND

SITE 3a

T. 1 N., R. 99 W., S. 4 - Lots 3 & 4; SW¼NW¼ - 120 acres - Surface is patented to Hugh Caldwell. Oil shale is reserved to the U.S.

S. 5 - SE¼NE¼; SW¼NW¼; SW¼SW¼; E½SW¼; W½SE¼; NE¼SE¼ - 320 acres - Surface is patented to Hugh Caldwell. Oil shale is reserved to the U.S.

S. 6 - S½NE¼; SE¼NW¼; SE¼SE¼ - 160 acres - Surface is patented to Hugh Caldwell. Oil shale is reserved to the U.S.

S. 17 - SE¼SW¼ - 40 acres - Surface is patented to Hugh Caldwell. Oil shale is reserved tothe U.S.

S. 33 - Lots 1 thru 4; S½NW¼; N½S½ - 363.56 acres - Surface is patented to Minford Beard. Oil shale is reserved to the U.S.

S. 34 - S½NW¼; N½SW¼ - 160 acres - Surface is patented to Minford Beard. Oil shale is reserved to the U.S.

T. 1 N., R. 100 W., S. 1 - S½ - 320 acres - Surface is patented to Sterling Cook. Oil shale is reserved to the U.S.

S. 11 - SE¼ - 160 acres - Surface is patented to Sterling Cook. Oil shale is reserved to the U.S.

S. 12 - N½; SW¼ - 480 acres - Surface is patented to Sterling Cook. Oil shale is reserved tothe U.S.

Site 1a

III. SURFACE RESOURCES AND SURFACE USE

A. Vegetative Resources:

Characteristically, the vegetation is pinyon pine or Utah juniper in the locale. The two species may be in either pure stands or together in varying combinations. Big sagebrush is conspicuous on the rolling divides and open areas with the pinyon-juniper. 1942 range surveys by BLM show Area 1a is composed of approximately 95% pinyon-juniper cover, and 5% sagebrush-greasewood. The vegetation is primarily used for livestock and big game feed. It also serves as cover for smaller game species and in retarding soil erosion. Juniper is cut by local ranchers for fence posts and poles.

Site 1b

III. Surface Resources and Surface Use

A. Vegetative Resources

This general location has two destinct types of vegetative associations.

Pinon pine and/or Utah juniper may be in either pure stands or together in varying combinations. Big sagebrush is conspicuous on the rolling divides and open areas within the pinyon-juniper. Oakbrush or serviceberry and mountain mahogany with an understory of grasses constitute the other distinguishing vegetation.

1942 range surveys by BLM indicate about 60% of Area 1b is sagebrush type, while some 40% is Pinon-Juniper type. The vegetation is primarily used for livestock and big game feed. It also serves as cover for smaller game species, and in retarding soil erosion. Juniper is cut by local ranchers for fence posts and poles.

Site 1d

III. Surface Resources and Surface Use

A. Vegetative resources.

Characteristically, the vegetation for this Area is pinyon pine and/or Utah juniper. The two species may be in either pure stands or together in varying combinations. Big sagebrush is conspicuous on the rolling divides and open areas within the pinyon-juniper.

The 1942 range survey by BLM indicates about 67% pinon-juniper stand, and 33% sagebrush type comprise the Area. The vegetation is primarily used for livestock and big game feed. It also serves as cover for smaller game species, and in retarding soil erosion. Juniper is cut by local ranchers for fence posts and poles.

Site 2a

III. Surface Resources and Surface Use

A. Vegetative resources

Characteristically the vegetation is about 20% Mountain shrub type, oakbrush, serviceberry, mountain mahogany; and 80% sagebrush. The vegetation is primarily used for livestock and big game feed. It also serves as cover for smaller game species, and in retarding soil erosion.

Site 2b

III. Surface Resources and Surface Use

A. Vegetative Resources.

This general location has two distinct types of vegetative associations.

Pinon pine and/or Utah juniper may be in either pure stands or together in varying combinations. Big sagebrush is conspicuous on the rolling divides and open areas within the pinyon-juniper. Oakbrush or serviceberry and mountain mahogany with an understory of grasses constitute the other distinguishing vegetation.

The BLM's 1942 range survey indicates the sagebrush type composes about 40% of the vegetation in the Area while the pinon-juniper and mountain shrub types each make up 30%. The vegetation is primarily used for livestock and big game feed. It also serves as protective cover for smaller game, and in retarding soil erosion.

Juniper is cut by local ranchers for fence posts and poles.

Site 2c

111 Surface Resources and Surface Use

A. Vegetative resources.

Vegetation is generally oakbrush, serviceberry and mountain mahogany, with an understory of grasses.

BLM's 1942 range survey indicates that mountain shrubs comprise about 35% of the vegetation; pinon juniper about 30%; sagebrush 20%; and half shrubs 15%. The vegetation is used primarily for livestock and big game feed. It also serves as a protectant against soil erosion, and as cover and habitat for smaller game.

Some juniper is cut by local ranchers to satisfy their fence post and pole needs.

Site 3a

III. Surface Resources and Surface Use

A. Vegetative Resources

This general location has two distinct types of vegetative associations.

Pinon pine and/or Utah juniper may be in either pure stands or together in varying combinations. Big sagebrush is conspicuous on the folling divides and open areas within the pinon-juniper. Oakbrush or serviceberry and mountain mahogany with an understory of grasses constitute the other distinguishing vegetation.

The 1942 range surveys by BLM indicate the Area is composed of about 45% pinon-juniper, 40% mountain shrubs, and 15% sagebrush. The vegetation is used mainly for livestock and big game feed. It also serves as cover for smaller game species, and in retarding soil erosion. Juniper is cut by local ranchers for fence posts and poles.

III. Surface Resources and Surface Use

B. Wildlife and Hunting

1. Wildlife Habitat Values

Colorado's Piceance Creek Basin, encompassing an area of approximately 650,000 acres, constitutes one of the state's most important mule deer range areas. It serves as the principal wintering grounds for the migratory White River herd which summers on high National Forest lands to the east and for a large percentage of the migratory population utilizing summer range on the Roan Plateau (Book Cliffs) area to the south. Rough estimates suggest this basin provides at least a portion of the winter forage for up to 15-20 percent of the total state deer population.

Within this important area is currently found a combination of vegetative, climatic, and cultural conditions adequately providing for basic mule deer habitat needs. The broken topography of valleys, streams, and mesas offers wildlife a broad variety of slopes, exposures, and vegetative communities. Large acreages of pinyon-juniper forest are interspersed with sagebrush-dominated open parklands and irrigated streambed meadows. The well-vegetated rangeland contains a wide variety of grass, forb, and woody browse species of sufficient quality and density to accommodate large numbers of wintering animals. Individual browse species of particular importance to mule deer, and found in significant quantity, include serviceberry (Amelancier alnifolia), mountain mahogany (Cercocarpus montanus), antelope bitterbrush (Purshia tridentata), and big sagebrush (Artemisia tridentata).

Numerous game-range studies conducted on mule deer populations have generally confirmed that in range areas north of 36° N. latitude major habitat limitations are found within winter use zones. This winter-range limitation appears to be particularly applicable to the White River and Roan Plateau herds. At 39.5° N. latitude, a line generally transecting the Piceance Creek Basin, the greater portion of range habitat suitable for mule deer winter-use is found within the elevational zone ranging from 5,500 to 7,500 feet. It is significant that approximately 95 percent of the land area within the Piceance Creek Unit falls within this critical elevational range.

The aesthetic, recreational and economic values of a big game resource can be maintained at optimum levels through preservation of basic habitat, and through the annual, sustained-yield harvest of surplus populations. Since a great portion of Colorado's fall deer migrations occur prior to or during the state's general or "post" hunting seasons, the winter range areas play a major role in annual harvest programs. Suitable public access must be provided if game resources are to be properly utilized and deer herds maintained at population levels consistent with available habitat.

The boundaries of the Piceance Basin shale resource area coincide directly with Colorado Department of Game, Fish and Parks' Game Management Unit No. 22. The value of this unit as a favored deer range and hunter use area is revealed through a review of annual game-harvest statistics.

During a 10-year period between 1957 and 1966 an average of 6,377 deer were harvested annually from within the 650,000-acre unit. This key range, constituting approximately 1 percent of the Colorado area, has contributed up to 10 percent of the total deer harvest during some years.

Annual harvest totals in Unit 22 since 1957 have varied from a low of 2,408 in 1966 to a peak kill of nearly 12,000 animals in 1961. This variation, in large part, reflects the influence of management decisions designed to establish a favorable balance between deer populations and their habitat.

Over a 10-year period an average of 6,000 hunters participated annually in Unit 22 deer harvests. When using an assigned factor of 2.5 hunter-days per sportsman's visit, deer harvests alone provide an average 15,000 recreational days use annually within the Basin. To this total may be added thousands of days recreational participation by tourists and visitors who enjoy observing deer on winter habitat or to witness the spectacular herd concentrations associated with spring deer migrations on the Piceance.

The importance of the Piceance Creek Basin game-range resource is attested to by the Colorado Department's continuing efforts in its preservation, management, and maintenance. Throughout the past two decades this agency

has acquired fee title ownership to more than 26,000 acres and cooperative resource management control over approximately 150,000 acres of key Basin habitat; conducted a continuing and systematic series of game-range investigations; and has promoted the development of a road system for provision of public access. For many years this big-game resource area, centered within the heart of the White River Plateau, has constituted the base for an important recreational enterprise, providing benefits for the nation's sportsmen, local ranchers, businessmen, and the general economy in surrounding communities.

Although the mule deer is of prime importance, populations of a number of other wildlife species are present within the Basin, contributing to its aesthetic, recreational, and economic potential. Grouse, ducks, rabbits, lion, doves, chukars, and miscellaneous non-game species are normally present. Seasonal use by limited numbers of elk is not uncommon.

With the anticipated initiation of oil shale mining and processing operations in the Piceance Creek Basin through test lease incentives, major habitat changes affecting the wildlife resource can be anticipated. On areas directly involved, surface modifications related to mining, processing, and spoil disposal will undoubtedly eliminate considerable amounts of game forage and cover. On a broader scope, these operations could have an adverse effect on general wildlife

populations and harvests through alteration of water supplies, migration routes, and the availability of public access. The addition of an industrial complex, with accompanying personnel and machines, could have a disruptive impact on wildlife populations and use patterns in range areas well beyond the immediate zone of development or mining operations.

The successful development of efficient and economic shale processing techniques envisioned in the test-lease program could result in the subsequent initiation of large-scale mining operations within the next decade or two. Land management agencies must, therefore, be fully prepared to offer direction and guidance with the objective of minimizing surface damage or disruption, as well as to seek means for orderly restoration of affected land areas. As appropriate, industrial lease terms should entail Departmental approval of proposed mining, restoration and revegetation plans and specifications.

Economic resource returns to industry and the primary landowner are expected to be of considerable magnitude per unit of area mined, therefore it can be assumed that land ~~restoration~~ rehabilitation costs will not be a factor limiting prompt and systematic restoration of defaced lands. The physical treatment and restoration practices effective in treating oil shale spoil may well be dependent upon application of specific methods or techniques not currently available.

It is of primary importance that systematic studies and experiments on waste-shale restoration and revegetation be initiated by a qualified research staff as spoil deposits materialize through proposed test-lease operations. Staff efforts should also be directed toward a comprehensive review and evaluation of applicable research studies on range reseeding, renovation and related programs including those associated with surface mining operations for coal or uranium.

The anticipated development of a shale oil industry within Colorado's Piceance Creek Basin can be expected to alter wildlife populations, their habitat, and recreational harvests by sportsmen. The extent of predicted changes will be dependent upon the scope of operations, the time schedule, and the adequacy of restoration or ~~restoration~~ rehabilitation efforts. On isolated mining tracts, precautions should be taken, as practicable, to reclaim key habitat sites; water supplies should be preserved or replaced in kind; and provision made for unrestricted public access to adjacent lands. Disrupted surface areas should be restored and reseeded promptly, using appropriate species and methods as may be required to replace lost forage.

Wildlife habitat values temporarily or permanently lost at development sites may be replaced in part through application of suitable ~~restoration~~ enhancement practices on adjacent undisturbed portions of native range. On select

areas, ~~restoration~~ rehabilitation processes, including pinyon-juniper removal, reseeding, livestock reduction, or fertilization should be considered since they may partially alleviate the adverse impact of game habitat losses.

Through various processes of ecologic succession, cultural activities, and management direction, the current vegetative composition within the Piceance Basin adequately provides wildlife forage and cover, particularly as related to mule deer winter-range requirements. Considering the various imponderables inherent in the proposed restoration of oil shale spoil, it is quite unlikely that existing wildlife values can be retained within the Basin in the advent that extensive processing operations materialize. Even though vegetative re-establishment on spent shale beds is accomplished, it must be capable of providing sufficient quantity and nutritive quality, and must be available in time and place equalling native productivity, if the existing game-range value of the Piceance Unit is to be retained.

The expected adverse impact of oil shale processing operations on game populations, habitat, historic migration routes, and public recreational use will undoubtedly be directly related to the size and intensity of mining programs. This impact will not be confined exclusively to specific mining sites or to the defined boundaries of the Piceance Creek Basin. With anticipated loss of winter forage and disruption of seasonal migration patterns, the overall aesthetic, economic and recreational potential of the White River and Roan Plateau deer herds would be expected to decline.

Anticipated shale oil developments through test-lease operations will have little detrimental impact on sport fishing since only limited resources exist within the Piceance Creek Basin. Water areas currently providing sport fishing opportunities are limited to a few acres of isolated beaver ponds on upper portions of Piceance tributaries and several small spring-fed reservoirs in stream valleys, constructed primarily for private recreational use. Retention of these small fishery resource areas could be accomplished through selective site reservation; however, the overall impact of oil shale mining operations on stream flows, spring origins and surface drainages are relatively unknown factors.

Industrial shale processing activities may result in the creation of large volumes of disposable water. Involved are normal surface drainage volumes, as well as anticipated supplies associated with mine de-watering and as a by-product of shale reduction processes. Through proper handling and treatment these anticipated surplus waters could be impounded and utilized for the development of an important sport fisheries resource within the Basin.

Precautions must be taken to prevent downstream pollution of existing fishery resource potentials through oil shale developments. Waters of the White River have considerable value for cold-water fishing above the Wolf Creek confluence, 47 miles downstream from Meeker and for warm-water fishing below that point. In addition, an important trout fishery has been created through reservoir construction by the Colorado Dept. of Game, Fish and Parks adjacent to the White River immediately above the moutn of Piceance Creek.

3. Test Lease - Site Selection Priority

Joint selection of three alternate test-lease sites within resource groups 1 and 2 was accomplished by task force members during arranged meetings scheduled July 24 and July 29, 1968. In addition, one tract, identified as having shale-oil recovery potentials similar to group 1 and 2 in combination, has been designated site 3(a).

The anticipated impact of shale oil processing on surface features, particularly as related to wildlife and recreational use, is presented by individual site as a contribution toward final test-lease selection.

a. Group 1 Tracts

The three sites, identified as 1(a), 1(b) and 1(d), lie within the heart of Piceance Creek Basin, encompassed by the Piceance-Yellow Creek drainages and their major tributaries. All Group 1 tracts have surface elevations falling within the critical 6-7,000 foot zone, thereby qualifying as important deer winter-range sites. Vegetative composition and density varies somewhat between individual tracts, however, all are characterized by mixed stands of Pinyon-Juniper with sagebrush in open parks. Associated browse, forb and grass species make up an understory growth, limited in density by annual precipitation levels approximately 13-14 inches.

Wildlife carrying capacities between individual tracts do not vary significantly, and provides little factual basis for site selection. Of greater importance for wildlife rating purposes is tract location in re-

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lation to public access requirements and anticipated industrial disruption within game-range units.

(1) Tract 1(a) - (Ryan Gulch)

Location - T. 1 S., R. 98 W. -- T. 2 S., R. 98 W.

Elevational Range - 6,200 - 6,700 feet -- Ave. 6,500 feet

Habitat - Pinyon-juniper, sage, mixed browse. Excellent deer winter range.

Wildlife - Mule-deer numerous. Suitable range for sage grouse, chukars, rabbits and doves.

Access - Of extreme importance. Primary route for public recreation use of Cathedral Bluffs region. Particularly significant in relation to Colorado Department of Game, Fish and Parks management area operations. Guarantee of replacement access mandatory.

Disruptive Influences - Tract currently receiving impact of high vehicular traffic on Ryan Gulch road and seasonal livestock movements between Square S-Ranch summer and winter range areas.

Summary - Test Lease Priority No. 1 - Selection of tract 1(a) for test-lease operations would entail a minimum penetration within undisturbed or primitive portions of winter-range habitat. Provisions

for suitable public access and surface restoration required.

2. Tract 1(b) - (84 - Mesa)

Location - T. 1 S., R. 99 W.

Elevational Range - 6,400 - 6,800 feet -- Ave. 6,600 feet

Habitat - Pinyon-juniper, sage, mixed browse. Excellent for deer winter range and sage grouse.

Wildlife - Mule-deer winter range. Contains sage grouse strutting ground, potential for chukars, doves and cottontails.

Access - Contains important road systems used extensively by public for recreational activities.

Disruptive Influences - Relatively remote area, currently little affected by vehicular or human penetration other than during scheduled game seasons or in conjunction with livestock operations.

Summary - Test Lease Priority No. 3 - Shale oil development would result in significant loss of deer and grouse habitat, and result in a disruptive industrial penetration of a remote game range area.

3. Tract 1(d) - (Yellow Creek)

Location - T. 1 N., R. 98 W. -- T. 1 S., R. 98 W.

Elevational Range - 6,300 - 6,550 feet -- Ave. 6,500 feet

Habitat - Pinyon-juniper, sagebrush, and associated browse.

grass and forb species. Within heart of mule deer winter range.

Wildlife - Mule-deer (winter), chukar, rabbit, dove and grouse.

Access - Not a significant factor.

Disruptive Influences - Remote area relatively little affected by human penetration other than during game harvest seasons.

Summary - Test Lease Priority No. 2 - Industrial penetration of lease site 1(d) considered less disruptive of winter range habitat or public access features than anticipated on site 1(b).

b. ~~2.~~ Group 2 Tracts

The Group 2 tracts generally lie in the southeastern quadrant of the upper Piceance Creek Basin. Adjacent tracts 2(a) and 2(b) are bounded on the north by Piceance Creek proper whereas tract 2(c) lies on the Rio Blanco-Garfield county line, well up the Willow Creek-West Stuart Gulch drainages. Tract elevations are generally well above 7,000 feet, placing them in the marginal or upper zone of deer winter-use ranges. At these elevations habitat is often inaccessible to deer because of snow depth, particularly on north facing slopes. This habitat area often has considerable spring-fall deer value, however, and may become increasingly important as wintering range for an expanding elk resource which is currently utilizing portions of this drainage.

Vegetative composition within Group 2 tracts is characterized by mixed stands of pinyon-juniper, Douglas fir or Aspen, associated with open sage parks and scattered communities of various mountain browse species. A moderately dense understory stand of grasses and forbs develop under annual precipitation levels averaging approximately 18-20 inches.

As with Group 1 tracts, differences in wildlife carrying capacities between individual Group 2 sites is of lesser significance for rating purposes than is the anticipated impact of shale processing on public recreational access and the industrial penetration of relatively remote range areas.

(1) Tract 2(a) - (Story Gulch)

Location - T. 3 S., R. 95 W.

Elevational Range - 6,800 - 7,800 feet -- Ave. 7,500 feet

Habitat - The productive game range habitat generally lies on north facing slopes within an elevational zone above dependable deer winter-use areas. The unit has considerable potential for wintering elk, and, depending upon varying climatic factors, often serves as yearlong range for significant numbers of deer.

Wildlife - Mule-deer, elk and grouse.

Access - Public access to adjacent game ranges generally restricted through current actions of controlling landowners. Through shale oil development, public access could be improved.

Disruptive Influences - Tract 2(a) is currently receiving disruptive impact of high vehicular traffic on Piceance Highway, and intensive livestock operations adjacent to Piceance Valley headquarter ranches.

Summary - Test Lease Priority No. 1 - Selection of tract 2(a) for test-lease operations would entail a minimum industrial penetration within undisturbed wildlife habitat, and may provide additional opportunity for public recreational access.

2. Tract 2(b) - (Stuart Gulch)

Location - T. 3 S., R. 96 W. -- T. 4 S., R. 96 W.

Elevational Range - 6,600 - 7,800 feet -- Ave. 7,500 feet

Habitat - Same as tract 2(a)

Wildlife - Same as tract 2(a)

Access - Same as tract 2(a)

Disruptive Influences - Area currently exposed to varying amount of human influence including vehicular traffic on adjacent Piceance Creek Highway and livestock movements from nearby headquarters ranches.

Summary - Test Lease Priority No. 2 - Industrial penetration

of undisturbed game range areas through oil shale development may result in somewhat greater detrimental impact than on tract 2(a).

(~~c~~3) Tract 2(c) - (Willow Creek)

Location - T. 4 S., R. 97 W.

Elevational Range - 7,500 - 8,100 -- Ave. 7,800 feet

Habitat - Generally within mountain browse zone with pockets of aspen, Douglas fir and pinyon-juniper. Good vegetative productivity, however, tract generally lies above dependable deer winter-range zone. Considerable potential for wintering elk.

Wildlife - Seasonal use by deer, elk, grouse, rabbits, and occasionally ~~and~~ bear.

Access - Tract contains important system of roads serving extensive range areas on Roan Plateau. Public use generally restricted under existing land-use patterns.

Disruptive Influences - Tract 2(c) contains important game range which is relatively undisturbed other than through normal ranching or permitted game harvest operations.

Summary - Test Lease Priority No. 3 - Development of tract 2(c) would result in serious industrial penetration

of a relatively remote game range area.

~~B.~~ C. Group 3

Tract 3(a) - (Calamity Ridge)

Location - T. 1 N., R. 99 W. -- T. 1 N., R. 100 W.

Elevational Range - 6,800 - 8,100 feet -- Ave. 7,500 feet

Habitat - Intermixed stands of pinyon-juniper, sagebrush and mountain browse species, generally lying at upper boundary of critical deer winter-use zone. Significant contributions to deer habitat needs throughout all seasons, depending on various climatic factors.

Wildlife - Deer, lion, grouse, doves and rabbits.

Access - Area contains important network of roads providing public recreational access to the Calamity Ridge-Cathedral Bluffs area.

Disruptive Influences - Area currently remote and relatively undisturbed other than through normal livestock and game harvest activities. Industrial penetration would result in adverse impact within tract boundaries and adjacent wildlife range areas.

Summary - Test lease priority above that on all tracts within Group 1.

C. Pollution Problems

The nature and magnitude of potential water pollution problems associated with the commercial processing of oil shale and related minerals is presently unknown. It is believed, however, that the water pollution hazards connected with this industry could rival or even overshadow these connected with the mining and milling industry and the present salinity problems in the Basin.

1. Potential Water Pollution Problems

A wide variety of pollutants can be expected from the recovery, handling, retorting, and refining of oil shale, and from the related by-products industries as well as from associated municipal, commercial, and industrial support facilities. The nature and expected sources of major potential pollutants are briefly discussed in the following sections.

a. Mineral Pollution

Oil shale is a sedimentary organic-inorganic matrix which was deposited in an ancient deep stratified inland sea. The deposits were laid down under reducing conditions, in saline water. Therefore, saline minerals are a naturally expected element of the shale environment. Normally, permeability of the deposit is low; however, fracturing and subsequent weathering has opened solution channels which contain and transmit water. Wells drilled in the area encounter water under artesian pressure ranging in quality from 300 to over 3,000 mg/l of total dissolved solids, with sodium carbonates and bicarbonates being the predominant minerals.

In addition, the lower shale deposits of the Green River formation contain small crystals of dawsonite and nahcolite. Another important potential source of mineral pollution is the shale material itself. Shales which have passed through the retorting process are known as "burned shales." Heating to temperatures in the range of 300-900°C causes exfoliation and modification of the physical and chemical shale structure. Limited analyses of the Colorado River Basin Water Quality Control Project laboratory indicate that burned shale rapidly releases significant amounts of minerals upon exposure to leaching (see Figure)

Any oil recovery process will require the removal of connate saline waters. This water will flow or be pumped from room and pillar mines to prevent flooding. Conventional or other, in-situ retorting processes will require dewatering to prevent quenching of the retort-heat source. Thus, disposal of existing saline ground waters will be expected to present a major problem in the early stages of development.

Recovery and processing of shales in the upper zones, which contain the richest deposits, may expose the lower zone shales to leaching. Salts leached from these shales could emerge in springs far from the point of shale recovery. In-situ processes may use live steam. Water associated (chemically and physically) with the shales will be released by heat from the retorting processes. Water from these sources could also serve to leach minerals from the inplace deposits. This water would emerge either at the oil recovery well or in remote springs.

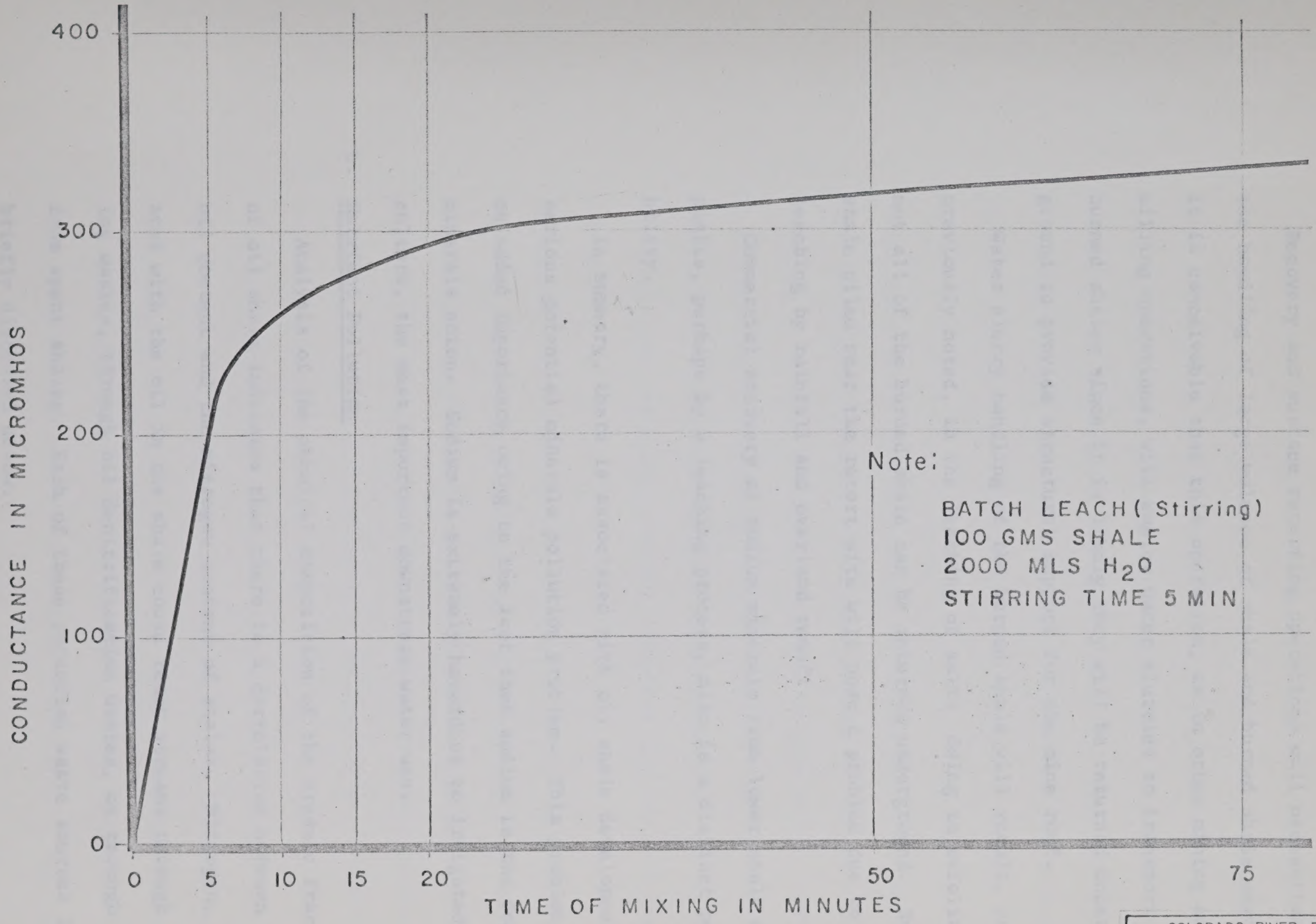

Figure . Leaching Experiment of Spent Shale in Distilled Water

Table #6

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTHWEST REGION SAN FRANCISCO, CALIF.

Recovery and surface retorting operations will necessitate the handling of large volumes of shale and burned shale wastes. It is conceivable that this operation, as in other mining and milling operations, will employ water slurries to transport burned shales since it is likely they will be returned underground to provide structural support for the mine roof.

Water slurry handling of the burned shale will result, as previously noted, in the leaching of salt. Owing to exfoliation, not all of the burned shale can be returned underground. Burned shale piled near the retort site will pose a problem due to leaching by rainfall and overland runoff.

Commercial recovery of sodium minerals from lower shale deposits, perhaps by a leaching process, also is a distinct possibility.

In summary, there is associated with oil shale development a serious potential minerals pollution problem. This problem takes on added importance owing to the fact that sodium is the dominant minerals anion. Sodium is extremely hazardous to irrigated agriculture, the most important downstream water use.

b. Nutrient Pollution

Analysis of the chemical composition of the organic fraction of oil shale indicates that there is a correlation between the oil content and the nitrogen content of shales. Nitrogen, associated with the oil in the shale could reach streams through retorting wastes, through oil denitrification wastes, or through leaching from spent shales. Each of these potential waste sources is briefly discussed below.

A wide variety of organic nitrogen compounds are expected from the retort. In conventional retorting, these compounds occur in the process water or in water released from the shale. In in-situ retorting nitrogen is released as nitrogen gas, or as partially oxidized organic nitrogen compounds. Such gases would be collected along with the vaporized hydrocarbon products, and would have to be separated for disposal or for processing as a by-product.

Oil as it comes from the retort is viscous and would be a solid at room temperature. This presents one of the most serious obstacles to in-situ retorting. The oil at this stage is 50 to 65 percent pure hydrocarbons with the remainder being organic compounds of sulfur, nitrogen and oxygen. Analysis of the oil extracted from the richest shales indicates that it is 2.4 percent nitrogen.

Because the oil is viscous, it must be partially processed at the site. Coking is an example of such processing. In coking, the oil is heated under pressure to drive off lighter oils as vapor and to convert the heavier fractions to coke. Minor amounts of sulfur or nitrogen, considered to be impurities, are removed in this process.

Hydrogenation, the contacting of hydrogen and a catalyst with the oil under high pressure and temperature, is the next step in processing of the shale derived oil. Hydrogenation produces pure oil with very little sulfur or nitrogen. These by-products, unless recovered, present real waste disposal problems.

Some nitrogen may remain in the inorganic residue of burned shale. Subsequent biological breakdown of these materials in the burned shale pile could release them through leaching into the aquatic environment.

Different processes have different amounts of nitrogen-bearing materials in the retort waste water, retort product oil, and burned shale, however, each of these intermediate materials presents an opportunity for these compounds to enter the aquatic environment unless pollution controls and safeguards are provided.

In addition to the nutrient sources from oil shale processing, substantial communities will be required to provide labor, and municipal and commercial support. Depending upon the scale of development, from ~~25,000~~ 5,000 people for 50,000 barrels per day, to ~~600,000~~ 225,000 for 2,000,000 barrels per day may be associated with this operation. Treated domestic wastes from such communities, if superimposed upon a substantial nutrient load from the industry may cause major nutrient pollution problems downstream.

In summary, nutrients from the oil shale development are certain to cause major water pollution problems unless steps are taken to eliminate, or control, nitrogen-bearing process wastes, and associated municipal and industrial wastes.

c. Radioactive Wastes

The Atomic Energy Commission, under a project called "Plowshare," is seeking to develop industrial uses of atomic energy. One proposal is the use of a nuclear device for the retorting of oil shale. Two special hazards exist in this connection. First,

fracturing and solution of the rock may increase its permeability, to the point where a formation normally dry will become an aquifer. Unless some means can be found to dewater the retort area and to assure that it remains dry (or unless some permanently dry area can be located), a potential for transport of radioactive pollutants will be created. V. Dean Allred, of the Denver Research Center, Marathon Oil Company, investigated acid leaching of shale for the purpose of improving permeability.[1] He found that a ten percent acid solution had no effect on the unretorted shale, but shale which had been fired to 1000°F rapidly disintegrated into a fine silt when placed in the dilute acid. The conclusion was that dilute acids could be used to enlarge permeability paths in burned shale. Ground water could cause similar weathering and solution channelization over a longer time period, thus allowing water movement through the burned shale surrounding the nuclear retort area.

The oil shale formation overlies a deposit containing brackish water, methane and other gases under artesian head. A high energy explosion could cause penetration and upward leakage of brines into the shale aquifer. These brines represent another potential source of water which could cause leaching and transport of radioactive pollutants.

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[1] Allred, V. Dean. First Symposium on Oil Shale, Quarterly of the Colorado School of Mines, Vol. 59, Number 3, July 1964, p. 52.

A second problem involves the possible contamination of oil and by-product gases (CO_2, steam, NO_2, SO_2, etc.) emanating from a nuclear retorting operation. Over 90 percent of the organic material released will be in the form of gas. Proper control and disposal of this waste gas will be of paramount importance. If these materials are collected in the condensed steam, safe disposal will be an important water pollution control consideration.

d. Other Types of Pollution Problems

Other types of pollutants normally associated with oil processing and refining, and with municipal and industrial support facilities, may be expected from the shale oil industry. These include: organic compounds that may be lost, spilled, or wasted from the process in liquid form; sulfur removed from the oil in the hydrogenation process as previously noted; solid wastes from air pollution control devices; municipal wastes from the associated industrial communities requiring conventional treatment, or even tertiary treatment to achieve waste water reclamation or nutrient removal. Process wastes from potential satellite industries such as aluminum, soda ash, nitrogen fertilizer, sulfur products, power, etc., must also be considered.

Managing water quality in an environment characterized by such a multiple-industry complex and served by a limited water supply presents a serious and challenging problem. Far-sighted and perhaps unconventional measures will be required to assure that water quality is suitable for uses associated with oil shale development as well as for downstream uses.

3. Effect of Pollution from Oil Shale Processing

a. Leaching of Spent Shale

Preliminary laboratory analyses made by the FWPCA indicate that salts would be leached from exposed spent shale tailings piles. Calculations based on laboratory analyses (not necessarily representative of field conditions) show that as much as 16 pounds of salt might be leached annually from each ton of spent shale. This would result in a salt pollution load of 172,000 tons/year and 143,000 tons/year from the 25 gallon/ton and 30 gallon/ton grade shale area respectively, assuming a production of 50,000 barrels per day. Said salt loadings would increase salinity at Hoover Dam by about 10 and 12 mg/l, respectively, at long-term mean flows.

The lessee should be required to prevent any of the salts contained in the spent shale from reaching any surface streams or groundwater. The control method would be left to the discretion of the lessee but might involve storage of spent shale in ravines with adequate cover to prevent leaching, or return of spent shale to the mines.

b. Disposal of Ground Water

The pumpage of ground water necessary to keep mines reasonably dry is shown in Table 26 ~~1~~ Page 217. Calculations based on the values shown in the table reveal that between 9,000 and 37,000 acre-feet per year of ground water will have to be disposed of during the first year of operation, depending upon the site selected, and that after 25 years the quantities would be 1,000 to 21,000 acre-feet per year. Inherent in these calculations is the estimate that 5,000 acre-feet of the ground water will be used consumptively in the processing operation.

In order to show the magnitude of the pollution problem that would result from discharge of excess ground water to surface streams from each site, the pumpage rates after 10 years were chosen. The 10-year values were used because

they are intermediate between the one-year and 25-year values, and hence representative of the middle period of oil shale development, around 1980. Since the major portion of water users that are affected by changes in the concentration of Colorado River water are located below Hoover Dam, this stream location is used as a reference point. The changes in concentration of the Colorado River at Hoover Dam are shown in Table along with the costs or benefits would be incurred by downstream users. The table shows the changes that would occur based upon two assumptions: (1) that no control of excess ground water is provided, and (2) that 90 percent of the salt is removed by some desalination process (75 percent of the excess water would be discharged). These costs and benefits are related to the total dissolved solids content of the ground water and not to any particular constitutent. It is likely that the costs would be higher than those shown because sodium is one of the principal constituents. Sodium in irrigation water has a very detrimental effect on crop growth and since the principal use of water below Hoover Dam is for irrigated agriculture, the effect could be larger than shown. The costs to obtain 90 percent control of the salt load have not been calculated but generally would exceed the benefits shown. However, the Department's policy is to keep all salt from future operation of this nature from reaching interstate streams.

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Table #7

Table 7. Effect of Discharge of Excess Ground Water to Colorado River Water Users Below Hoover Dam

Site Number	No Control of Salt Load		90% Control of Salt Load	
	Change in Concentration at Hoover Dam (mg/l) 3/	Penalty Costs ($1/yr) 2/	Change in Concentration at Hoover Dam (mg/l) 1/	Penalty Costs ($/yr) 2/
1a	+ 12	551,000	0	0
1b	0	0	- 1	(-46,000) 3/
1d	+ 47	2,197,000	+ 3	138,000
2a	+ 2	92,000	- 2	(-91,000)
2b	+ 2	92,000	- 1	(-91,000)
2c	0	92,000	- 1	(-46,000)
3a	0	0	- 1	(-46,000)

1/ Based on concentrations and 10 year pumpage rates showin in Table , and on assumed consumption of 5,000 acre-feet/year of ground water for processing.

2/ Annual cost incurred by all Colorado River water users below Hoover Dam in 1980.

3/ (-) indicates benefit rather than cost.

4. Evaluation of Sites

In order to evaluate the test lease site from a water pollution aspect, the following criteria were chosen:

(a) least disturbance of saline formation,

(b) most favorable for disposal of retorted shales,

(c) least physical and economic detriment from saline ground water disposal.

The relative desirability of the sites, based upon the above criteria, is shown in Table .

a. Site Group 1

All three sites contain large quantities of saline deposits that will cause disposal and potential water pollution problem when disturbed. Geologic information indicates that less problems would occur in Site 1-b.

All sites in the group lie in the center of the basin, which is characterized by low relief with broad flat valleys. There are but few deep narrow valleys that offer good potential for disposal of retorted shale. Site 1-d offers the best potential (approximately 8 million cubic yards), but the difference is small. A tabulation of areas apparently favorable for spent shale storage at each site is give in Table .

The site offering the least ground water disposal problem is 1-b, since the anticipated volume of ground water pumping is smallest here, and the water is less saline than at either of the other two sites. From a ground water disposal standpoint, Site 1-d is by far the worst in both quantity and quality, in fact worse than 1-a and 1-b combined.

Table 8. Relative Desirability of Proposed Oil Shale Test-Lease Sites for Water Quality Management

Criteria for Evaluation	Site Group 1 (Central Area, Thick Strata)				Site Group 2 (Peripheral Area, Thin Strata)				Special Site in Greasewood Creek Watershed
	1a	1b	1c	1d	2a	2b	2c	2d	3a
1. Least disturbance of saline formations.	2	1	Dropped 7-29	3	Not applicable			Dropped 7-29	Unknown
2. Most favorable site for disposal of retorted shales.	2	3		1	1	2	2		Very favorable.
3. Least physical and economic detriment from saline ground water disposal.	2	1		3	2	2	1		Superior to any site in Group 1. Intermediate between (2c) and (2a, 2b) in Group 2.
Point Totals	6	5	-	7	3	4	3	-	

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Table #8

Table # 9

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Table 9. Estimated Volume of Shale Storage

Site Number	Name of Gulch	Location within Site (Section No.)	Volume (Cubic Yards x 10^6)
1a	Unnamed	Center of 1	3.9
	Unnamed	East part of 1	1.5
			Total = 5.4
1b	Unnamed	25	3.3
			Total = 3.3
1d	Unnamed	West part of 4	5.5
	Unnamed	34	3.2
			Total = 8.4
2a	Halfmoon	26, 35	33
	East Gordon	22, 27	24
	West Gordon	21, 28	29
			Total = 86
2b	Sprague	24, 25, 36	42
	Unnamed	14,23	33
			Total = 75
2c	Unnamed	15	5.8
	Unnamed	10	16.2
	Unnamed	South part of 3	9.6
	Unnamed	North part of 3	18
	Unnamed	8	25
			Total = 75
3a	Joe Ryan Draw	5, 6	37
	East Fork Greaswood	9, 10, 16, 17	50
			Total = 87
	Other available areas		Possibly 80

b. Site Group 2

The sites in this group are not underlain by very thick saline deposits and no pollution problems are anticipated from this cause.

There are numerous areas available for disposal of spent shale in this site group. Personal reconnaissance, and a careful study of topographic maps showed that Site 2-b offers the greatest surface disposal capacity for retorted shales. Some of the deep narrow valleys could be blocked by large dikes behind which retorted shale could be stored until it could be moved back underground. Approximately 86 million cubic yards of storage capacity (3½ years of processing wastes) could be obtained in Halfmoon Gulch, and in West Gordon Gulch in Sections 21 and 28, and East Gordon Gulches, as shown in Table . Sites 2-b and 2-c offer approximately the same storage capacity, but somewhat less than Site 2-a.

The potential pollution problem from excess ground water pumpage is least in Site 2-c in terms of both quantity and quality. Sites 2-a and 2-b are practically the same from this standpoint, and are only slightly worse than Site 2-c.

c. Site 3-a

The extent and thickness of saline formations in this area are unknown at present.

A site inspection, and a study of topographic maps, reveal that the potential areas for storage of retorted shale are numerous. Joe Ryan Draw and the East Fork of Greasewood Creek offer approximately 86 million cubic- yards of storage capacity. There are several smaller valleys within the site that have at least as much more capacity. From this aspect it is the most desirable of all sites.

For ground water disposal, Site 3-a is superior to any in Group 1. It is intermediate between Site 2-c and Sites 2-a and 2-b of Group 2.

5. Control Responsibility

A 1965 amendment of the Federal Water Pollution Control Act (Public Law 84-660) charged the States with the responsibility for enacting standards of quality for interstate waters. Said standards must be acceptable to the Secretary of the Interior and when approved by him, become Federal standards also. Violations are subject to Federal abatement, if necessary through legal action, in the manner provided for by law (Public Law 89-234).

The States directly affected by potential oil-shale development in the Piceance Basin, Colorado and Utah, have adopted water quality standards for all their interstate streams and important tributaries. These standards currently are being reviewed by the Secretary of the Interior. It is expected that they will be approved shortly.

Waters of the White River are classified by the State of Colorado* as suitable for public and agricultural water supply throughout the course of the river. In addition, they are to be protected for cold-water fishing above the Wolf Creek confluence, 47 miles downstream from Meeker, and for warm-water fishing below Wolf Creek.

The Yampa River is similarly classified. The division point between cold-water and warm-water fishing in this case is the confluence with Milk Creek, 22 miles below Craig. Limited industrial use at Craig is recognized also.

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* State of Colorado, Water Pollution Control Commission, Stream Classification for Surface Waters of Colorado, June 1967.

Contiguous waters in Utah, including the Green and Colorado Rivers, are similarly classified *. They are to be protected for use as public water supplies, after ordinary treatment; irrigation, stock watering, fish and wildlife propagation, and recreation except swimming.

Adoption of these standards implies strict limitation on the discharge of waste products from a shale oil industry. Oxygen-consuming discharges, including sewage and organic industrial waste products; spent cooling water and boiler blowdown; nutrient elements, including nitrogen and phosphorus; acid and alkaline process waters, and all substances toxic to man, to livestock and aquatic life, will be subject to close regulation.

Special attention will be attached to pollution by mineral salts. Owing to the complex technical and legal problems of salinity control, no specific numerical limits have been adopted as yet for dissolved mineral salts. The policy of the Basin states, and of the Federal Water Pollution Control Administration, is to restrain salinity to the economic minimum. This means that wherever feasible, saline waste water discharges must be so managed as to minimize pollution of public waters. This policy has been expressed by representatives of the seven Basin states in the following terms **:

> The States served by the Colorado River System recognize that answers to important questions regarding total dissolved solids chlorides, sulfates and sodium are lacking or are based on factors that are not yet well-defined. In respect of this recognition the States agree that pending the development of acceptable

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* Utah Water Pollution Control Board, Water Quality Standards and Implementation Plan, June 1967.

** "Guidelines for Formulating Water Quality Standards of the Interstate Waters of the Colorado River System", June 13, 1967.

answers to enable the setting of criteria for total dissolved solids, chlorides, sulfates and sodium for the interstate waters of the Colorado River System, such criteria should be stated in qualitative terms. At the same time it is agreed that all identifiable sources of water pollution will be managed and controlled to the maximum degree practicable with available technology in order to provide water quality suitable for present and potential future uses of the System's interstate waters.

Preliminary studies by the Federal Water Pollution Control Administration show that substantial penalty costs attach to use of mineralized water supplies, especially in the lower Colorado River Basin and in southern California. Under projected economic development and population of the year 2010, each part per million of increase in dissolved mineral solids at Hoover Dam will represent an added cost around $250,000 per year to downstream water users. Two Interior Department agencies, the Bureau of Reclamation and Federal Water Pollution Control Administration, recently began a formal study of means for controlling or abating salinity in streams of the Colorado River system, and certain control measures are already under way.

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COMMENTS ON RECREATION, CONSERVATION AND SCENIC VALUES IN THE PICEANCE BASIN, COLORADO

Submitted by the Mid-Continent Region
of the Bureau of Outdoor Recreation
as a participant on the Interior
Inter-Agency Oil Shale Test Lease
Site Selection Task Force

Background and Purpose

Several recommendations in Interior's recently released report, "Prospects for Oil Shale Development", called for immediate action. One such recommendation was to identify potential areas to be used for two test leases. One lease is to be located in thin deposits of oil shale, and the other in the thick, deep oil shale. A field task force, chaired by the Bureau of Land Management, was appointed to select and evaluate a number of sites in the Piceance Basin of Northwestern Colorado, believed to be suitable for test lease sites. These sites were selected and evaluated in terms of four basic criteria considerations: oil shale resources, mineral development, land status, and surface considerations. The Mid-Continent Region was requested to evaluate eight sites with respect to recreation potential and scenic values. Other surface considerations, such as water resources, pollution, wildlife and hunting use, vegetative resources, and land uses were assigned to other agencies for their evaluation.

The following comments are prepared for inclusion in the field report of the Interior Inter-Agency Oil Shale Test Lease Site Selection Task Force. In brief, this paper first describes the general recreation and aesthetic values of the Piceance Basin; secondly, it considers individual sites, and finally outlines suggested regulatory measures designed to minimize the impact of mining operations on the environment in order to retain, to a practical degree, the basin's scenic and recreation values.

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Scenic and Recreation Aspects of the Piceance Basin

The scenic and aesthetic values in the Piceance Basin can be described as moderate in relation to many other areas in Colorado. The scene is pleasant. While not the traditional Rocky Mountain splendor with rugged terrain and heavily forested slopes, the scene is by no means monotonous. Generally, the Piceance Basin consists of a series of narrow ridges and valleys radiating from the course of Piceance Creek. The ridges rise steeply from the stream bottoms, leveling off abruptly to form flat and rounded tops. The tops are frequently open with sagebrush and scattered juniper and pinon pine. Some areas, especially at higher elevations, are more heavily forested with conifers interrupted with aspen-filled draws leading to major stream bottoms. In sharp contrast to the semi-arid vegetative types found on the ridges, the valley bottoms display a lush grass cover, especially where irrigated.

With the exception of the inevitable degree of pollution occurring from livestock and farm operations, the environment of the Piceance Basin is relatively unpolluted. The fact that the basin is relatively free of pollution adds considerably to the scenic and aesthetic values of the area in question.

At the present time recreation is not of major significance in the Piceance Basin. Most recreation activity in the area is directly associated with hunting, for which the basin is quite popular during the fall months. Other activities which are well suited to the area but only occasionally experienced, are horseback riding, nature study, rock collecting and prospecting, jeep riding, artifact hunting and recreation activities associated with dude ranch operations.

Several reasons account for the apparent lack of recreation use in the Piceance Basin. Probably the most important reason can be attributed to location. The basin is fairly remote with the surrounding area only sparsely populated. Piceance Basin is a sub-basin of the White River Basin located mainly in three counties, Rio Blanco, Moffat, and Garfield. About 5,560 people resided in the White River Basin in 1960. More than 90 percent live in Rio Blanco County, with the remainder in Moffat County. There is no permanent resident population in the Garfield County part of the basin. Most of the population resides in three communities; Meeker and Rangely in Rio Blanco County, and Dinosaur in Moffat County. In 1964 Meeker had an estimated population of 1,660, Rangely, 1,600 and Dinosaur, 350 making a total urban population of 3,610.

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Another factor accounting for the present lack of recreation use in the Piceance Creek Basin is directly related to its recreation resources relative to those in other parts of the White River Basin. In other words, the Piceance Basin must compete with other parts of the White River Basin which are far more attractive for recreation purposes- thus being developed accordingly. Aside from offering 82,000 acres of the Flat Tops Primitive Area, the eastern end of the White River Basin includes developed campgrounds, resorts, tourist motels, excellent fishing waters, boating waters, and an overall more pleasing recreation climate.

The relatively minor importance of recreation in the Piceance Basin today should be regarded as strictly temporary. Should the Piceance oil shale resources be developed as envisioned, the entire area will take on a new appearance and importance. Demands on water and land resources will increase greatly in all respects including needs for recreation pursuits.

The entire White River Basin at present has a low population density of 1.5 people per square mile. Indications are that with industrial development, the growth rate will be extremely rapid during the next fifty years. Commercial and residential development can be expected to grow within and in close proximity to the Piceance area. Estimated population projections for the White River Basin show a phenomenal growth rate from the present time to year 2020, much of which can be expected to occur in the immediate vicinity of Piceance Basin.

Historical and Projected Population,
White River Basin 1/

Year	Estimated Population
1940	3,070
1960	5,560
1980	20,000
2000	186,000
2020	204,000

Projected Increases excessive

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The expected increase in population is based on manpower requirements for a 1,000,000 barrels per day production level. It includes the number of workers who would be directly employed in all phases of the

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1/ Water and Related Land Resources, White River Basin in Colorado. A cooperative study by Colorado Water Conservation Board and U. S. Department of Agriculture, November, 1966

production of oil from shale by presently feasible processes, their families, and the associated service and supply enterprises that would be required.

Increase of an area's population brings about a natural increase in demand for outdoor recreation facilities and space. For this reason alone, it is virtually imperative that recreation and aesthetic values in the Piceance Basin be carefully regarded in both the selection of oil shale test lease sites and ensuing operations.

Recreation and Scenic Aspects of Individual Sites

Eight specific potential lease sites were selected by the Field Task Force for evaluation. Two tracts (1-c and 2-d) were eliminated as being undesirable for development considering all factors. The remaining six consisted of three tracts located in the 50 foot, 30 gallon shale and three in the 1,000 foot, 25 gallon shale.

The following evaluation of recreation (excluding hunting and fishing) and scenic aspects of the six selected potential lease sites is based entirely on an aerial reconnaissance of the Piceance Basin and existing maps and inventory data. The various tracts are rated as high, moderate or low in terms of relative merit of one site to another.

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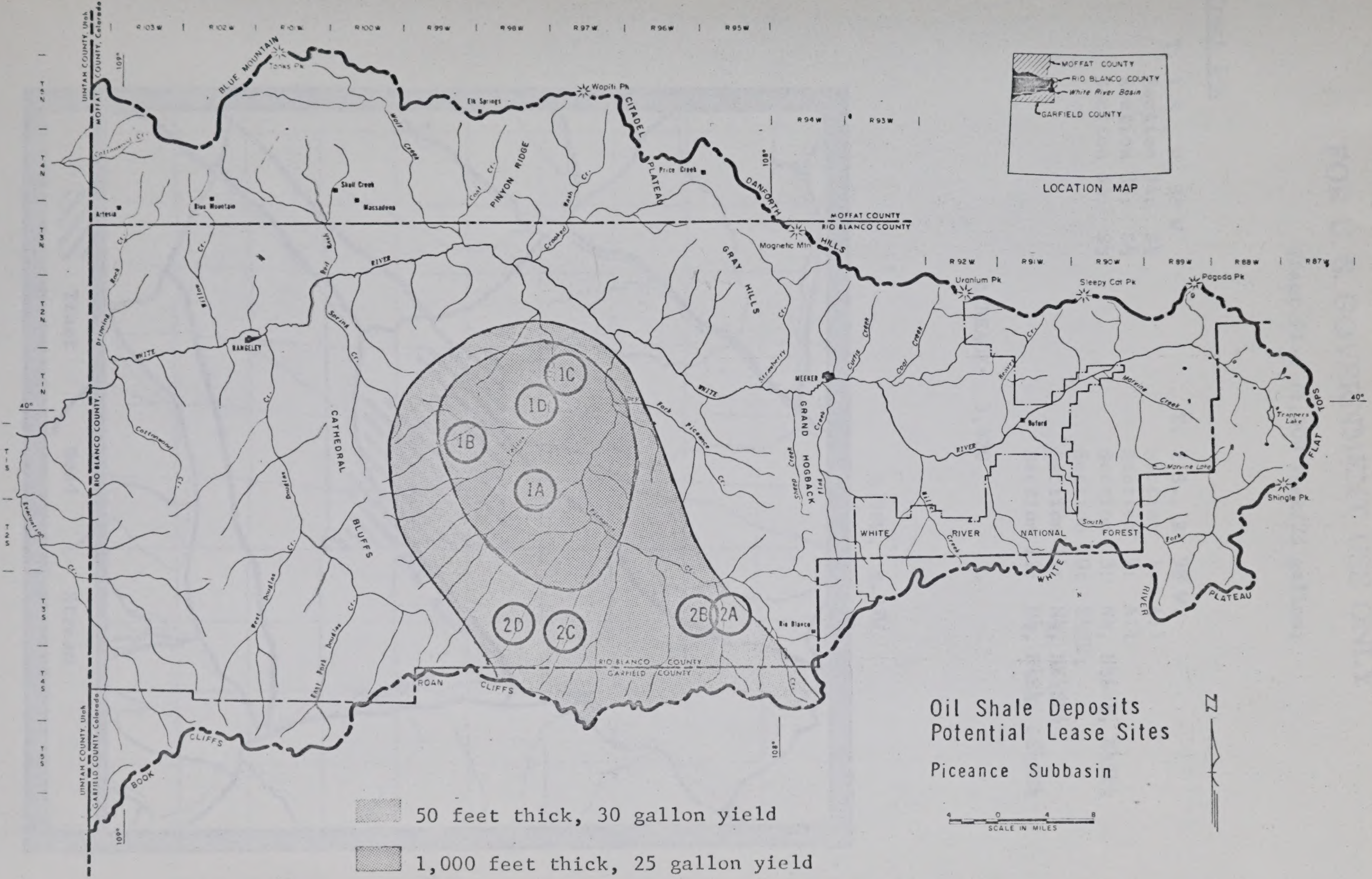

▨ 50 feet thick, 30 gallon yield

▨ 1,000 feet thick, 25 gallon yield

Oil Shale Deposits
Potential Lease Sites

Piceance Subbasin

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Table #10

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Table # 11

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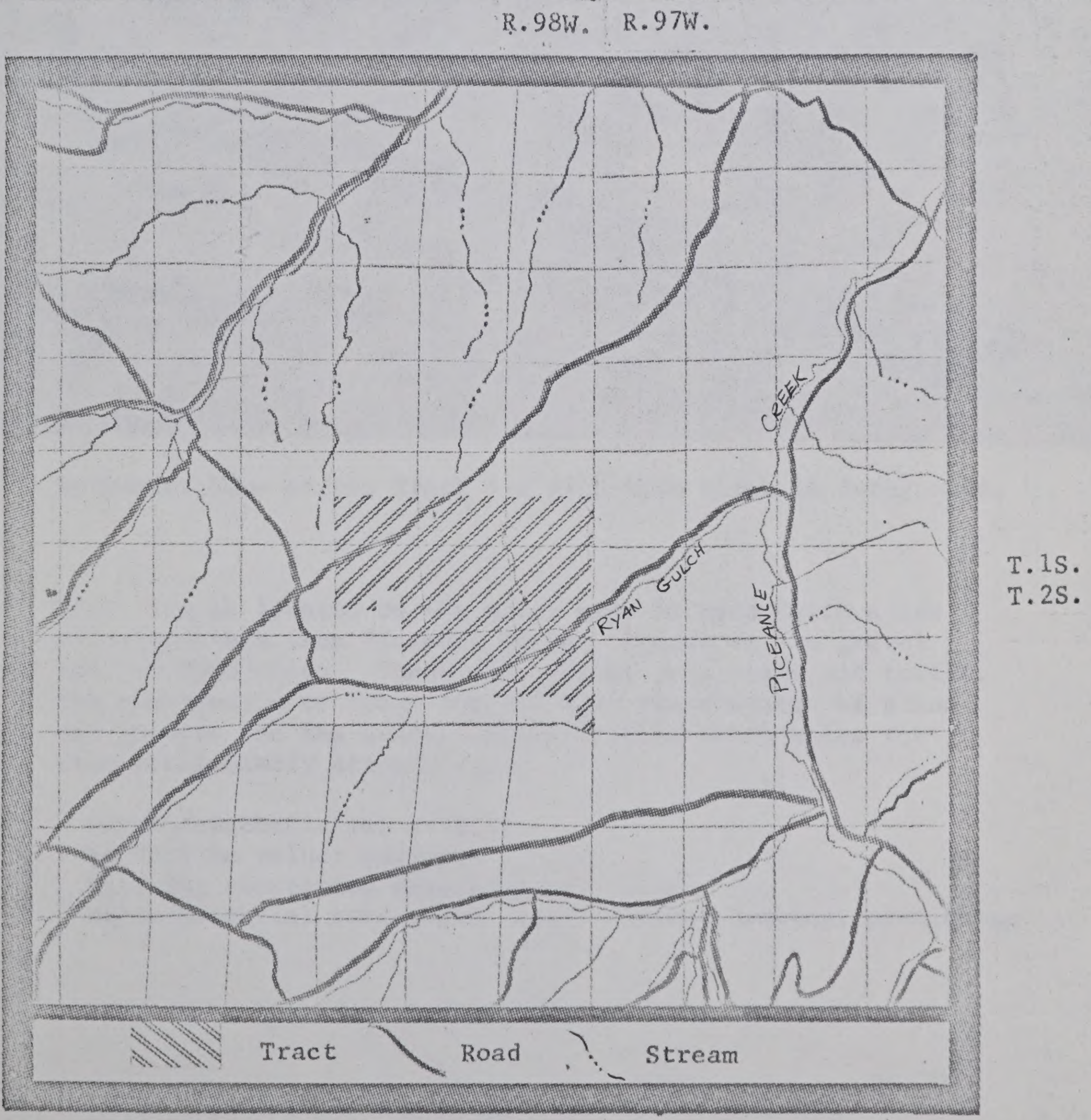
Tract #1-a (1,000 feet/25 gallon)

Tract 1-a

T. 1 S., R. 98 W.	T. 2 S., R. 98 W.
Section 34: S½	Section 1: All
Section 35: S½	Section 2: All
Section 36: S½	Section 3: N½, N½SW¼, E½SE¼
	Section 10: E½NE¼
	Section 11: N½, NE¼SE¼
	Section 12: N½, N½S½, SE¼SE¼

ACREAGE: 3,420



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Northwest view across Tract 1-a with Ryan Gulch in foreground.

Tract 1-a is located on the north side of Ryan Gulch a few miles upstream from Piceance Creek. Access is via gravel road up Ryan Gulch. There are several jeep roads and trails. The combination of rough terrain with dense stands of pinon and juniper and the grassy valley of Ryan Gulch makes the area particularly attractive.

Scenic/aesthetic value: high
Recreation value: moderate
Existing recreation developments: none
Major potential recreation uses: riding, camping, picnicking

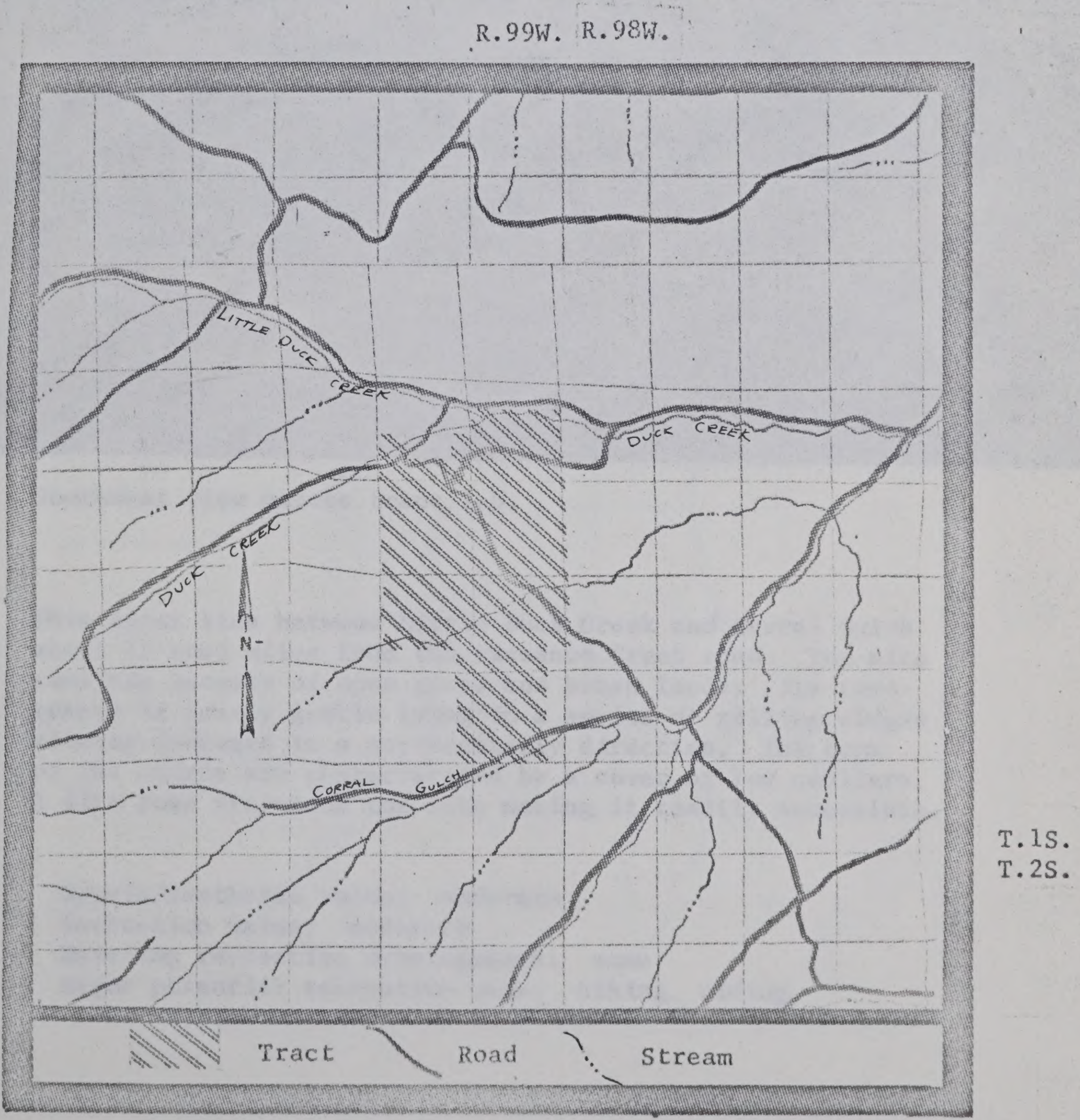
Table #12

Tract #1-b (1,000 foot/25 gallon)

Tract 1-b

T. 1 S., R. 99 W.
Section 11: W½SW¼, SE¼SW¼, NE¼SE¼, S½SE¼
Section 12: S½N½, S½
Section 13: All
Section 14: All
Section 23: N½, N½S½, SE¼SE¼
Section 24: N½, N½S½, S½SW¼, SW¼SE¼
Section 25: W½NE¼, W½, W½SE¼
Section 26: E½E½

ACREAGE: 3,840



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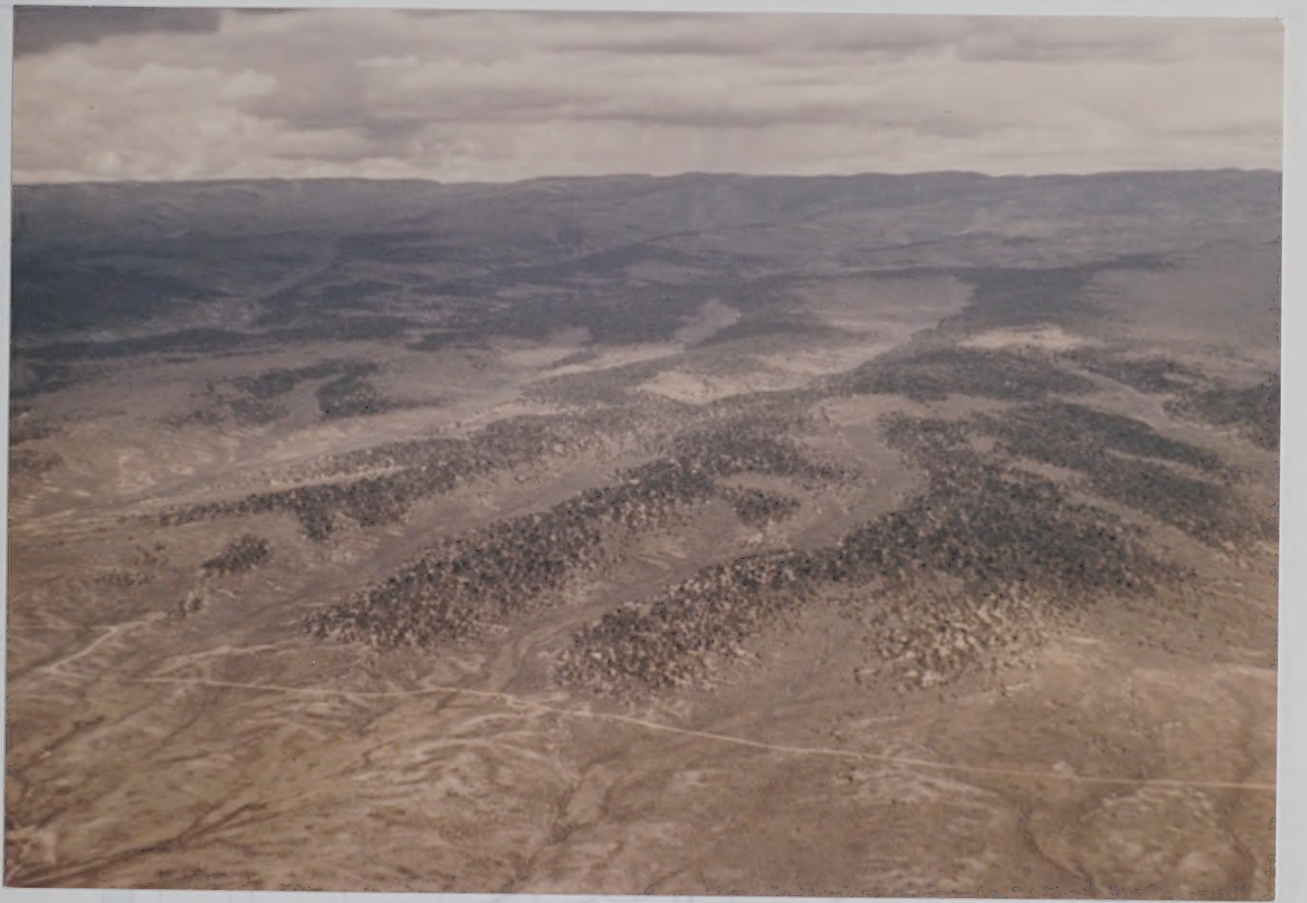

Southwest view across tract 1-b.

This tract lies between Little Duck Creek and Corral Gulch about 15 road miles from the Piceance Creek road. The site consists largely of open grass and brush lands. Its topography is fairly gentle lying in a series of rolling ridges sloping downward in a northeasterly direction. The tops of the ridges are characterized by a cover of low conifers. A dirt road traverses the site making it readily accessible.

Scenic/aesthetic value: moderate
Recreation value: moderate
Existing recreation developments: none
Major potential recreation uses: hiking, riding

Table 13

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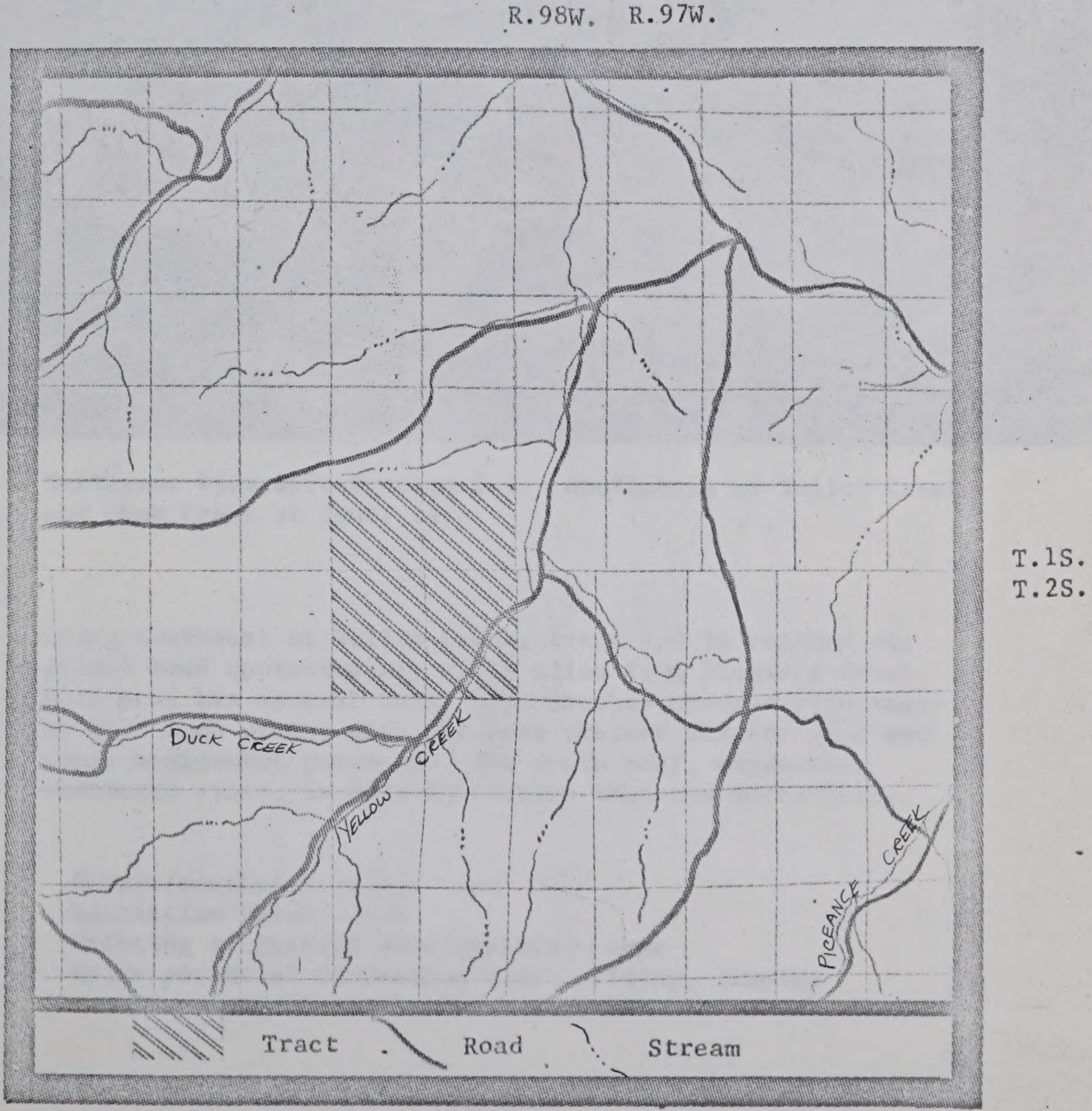
Tract #1-d (1,000 feet/25 gallon)

Tract 1-d

T. 1 N., R. 98 W.
Section 33: All
Section 34: All

T. 1 S., R. 98 W.
Section 3: All
Section 4: All

ACREAGE: 3,200



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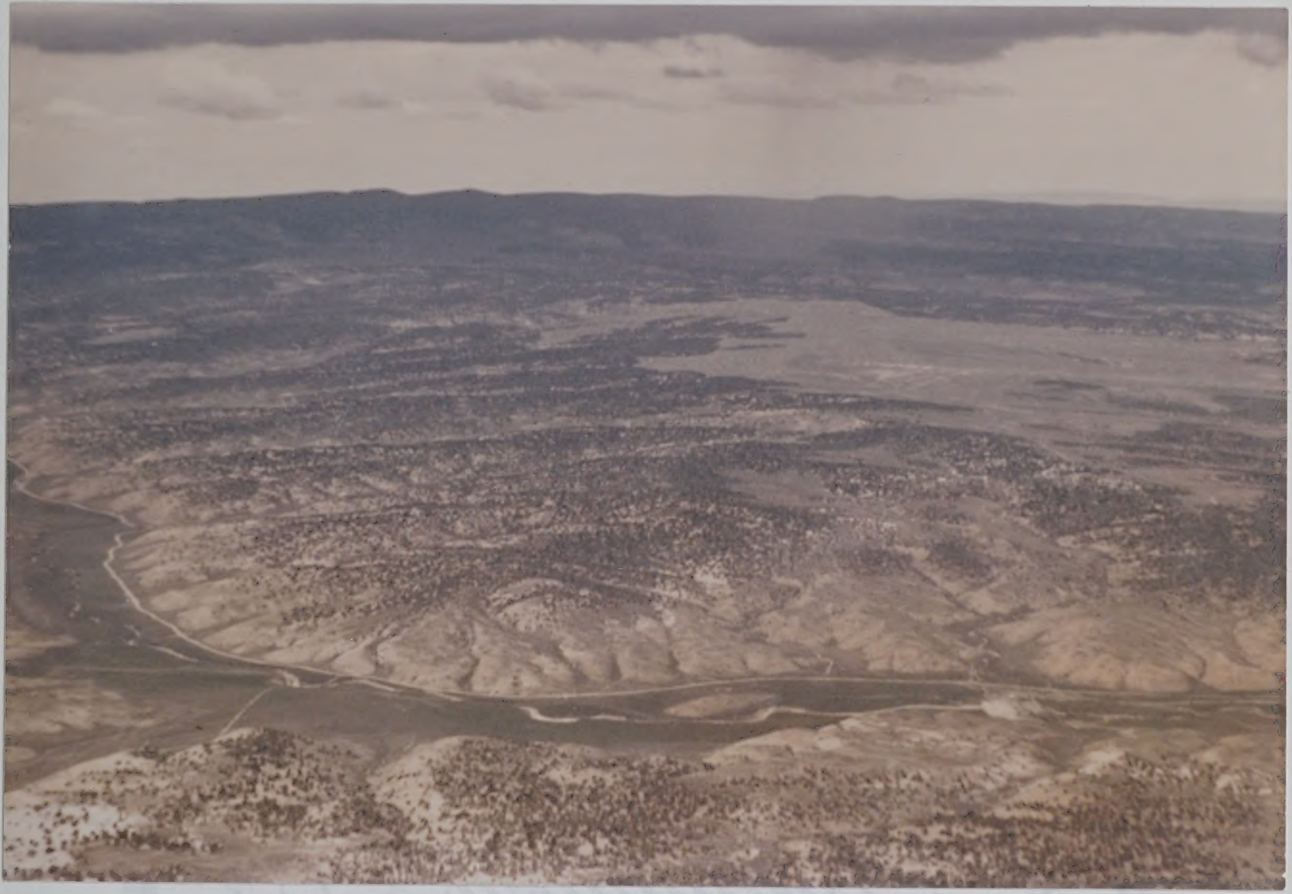


Northwest view across tract 1-d. Confluence of Yellow Creek and Duck Creek at lower left.

Lying northwest of Yellow Creek, tract 1-d is reached via gravel road approximately eight miles from Piceance Creek. This area has several large open benches covered with sagebrush. Much of the site has been chained off for game and range management purposes. The south half, supporting scattered pines, is more attractive than the north half.

Scenic/aesthetic value: low
Recreation value: low
Existing recreation developments: none
Major potential recreation uses: riding, camping

Table # 14

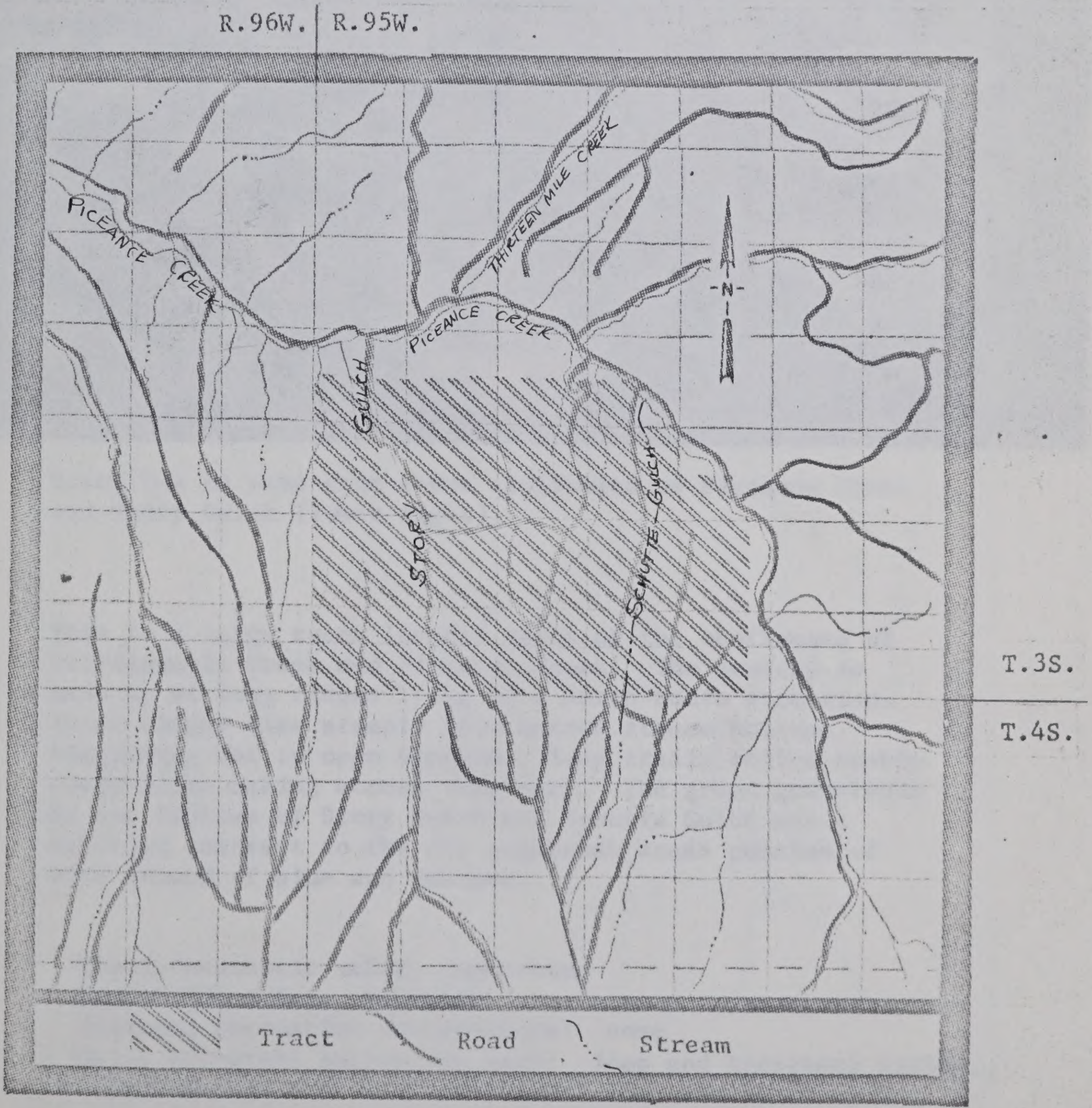
Tract #2-a (50 feet/30 gallon)

Tract 2-a

T. 3 S., R. 95 W.

Section 15: SW¼
Section 16: S½
Section 17: S½
Section 18: S½
Section 19: All except SE¼NE¼
Section 20: All
Section 21: All
Section 22: All
Section 23: SW¼
Section 26: All except E½E½
Section 27: All
Section 28: All
Section 29: All except NE¼NW¼
Section 30: All
Section 31: All
Section 32: All except NE¼NW¼
Section 33: All
Section 34: All
Section 35: All except E½E½

ACREAGE: 9,720



Tract 2-a as seen from above confluence of Piceance Creek and Story Gulch (lower right).

This is a large tract located south of the confluence of Thirteenmile Creek and Piceance Creek. The country is made up of long ridges lying in a north-south direction. These ridges rise steeply from narrow stream bottoms, flattening out to open benches. Jeep trails follow nearly every ridge making access very easy. The green grasslands in the bottoms of Story Gulch and Schutte Gulch are a striking contrast to the dry sagebrush areas punctuated with clumps of pine and juniper.

Scenic/aesthetic value: moderate
Recreation value: moderate
Existing recreation developments: none
Major potential recreation uses: jeep and horseback riding, picnicking

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Tract #2-b (50 foot/30 gallon)

Table #15

Tract 2-b

T. 3 S., R. 96 W.
Section 10: S½NE¼, SE¼NW¼, E½SW¼, SE¼
Section 11: S½NW¼, SW¼, W½SE¼
Section 13: SE¼NE¼, W½NW¼, SE¼NW¼, S½
Section 14: All
Section 15: NE¼, E½NW¼, S½
Section 16: S½
Section 21: All
Section 22: All
Section 23: All
Section 24: All except SE¼NW¼
Section 25: All except NE¼NW¼
Section 26: All except E½SW¼
Section 27: All
Section 28: E½
Section 33: NE¼NE¼, W½E½
Section 34: All
Section 35: NE¼, S½SW¼, SE¼
Section 36: All

T. 4 S., R. 96 W.
Section 1: W½, SE¼
Section 2: All
Section 3: All
Section 4: E½

ACREAGE: 11,280

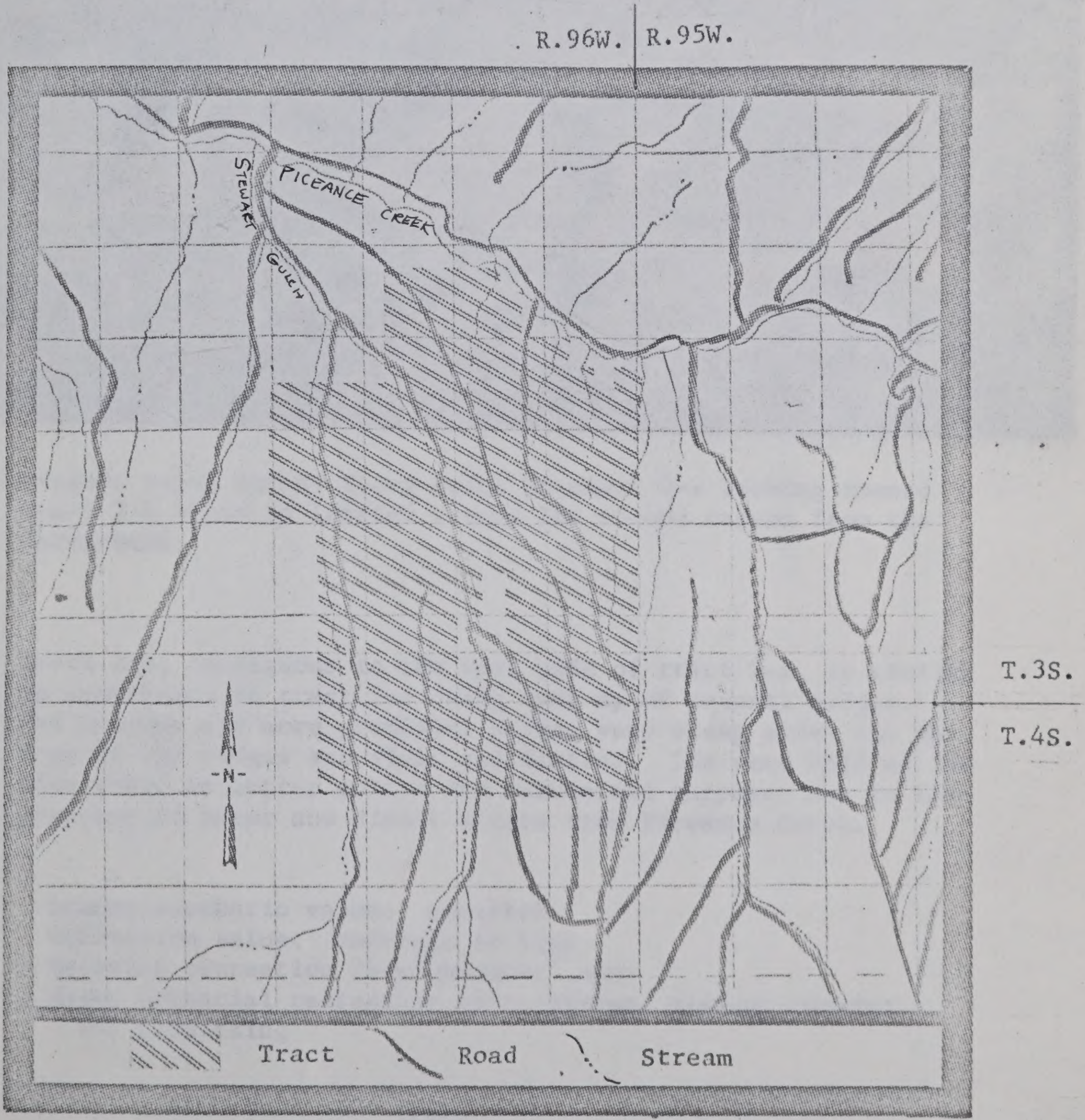
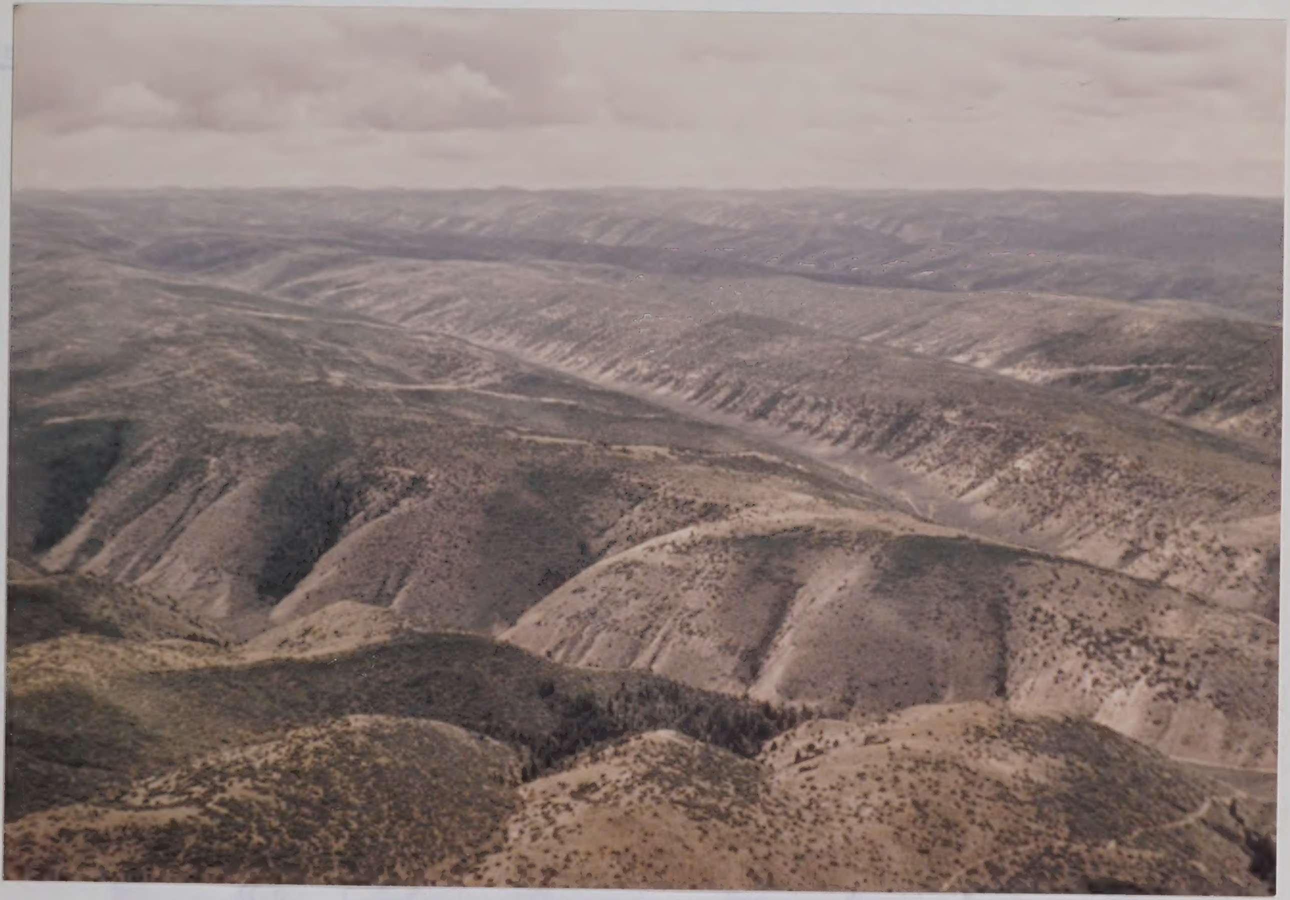


Table #16



Picture taken across Story Gulch in tract 2-a looking toward tract 2-b which is located behind the second canyon from the foreground.

Tract 2-b, contiguous to the west side of tract 2-a, is similar in appearance to tract 2-a being made up of several ridges. The canyons are more prominent having very steep sides and the tops of the ridges are wider and flatter. The west half of the site would be better suited for recreation purposes due to the presence of water and direct access from Piceance Creek.

Scenic/aesthetic value: moderate
Recreation value: moderate to high
Existing recreation developments: none
Major potential recreation use: hiking, riding, camping and picnicking

Table #16

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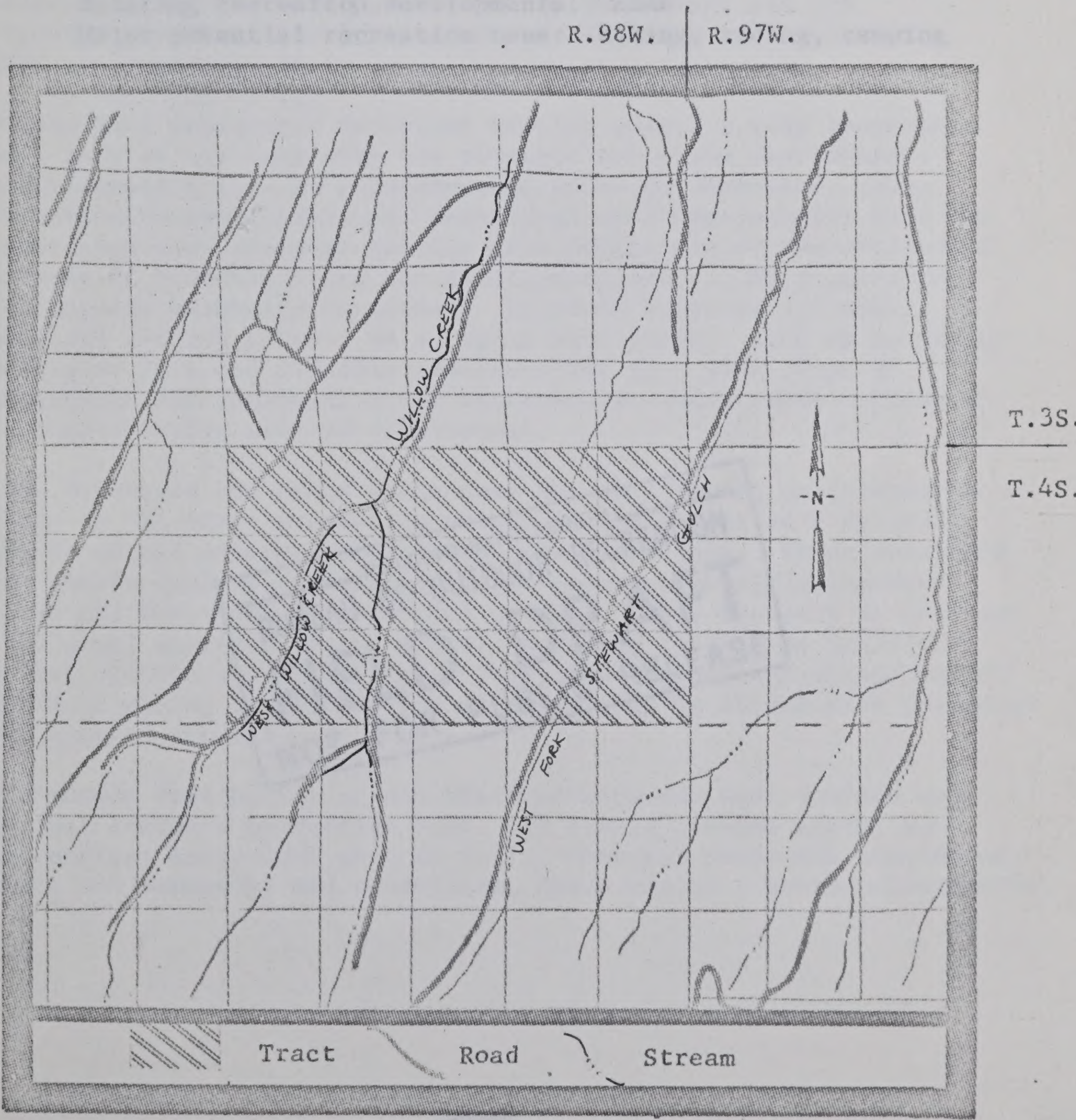
Tract #2-c (50 foot/30 gallon)

Tract 2-c

T. 4 S., R. 97 W.
Section 1 - 5: All
Section 8 -15: All
Section 16: All except SW¼NE¼
Section 17: All except NE¼SW¼

ACREAGE: 9,520



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This site is located near the headwaters of Willow Creek and has the highest elevation of the six sites chosen. The landscape consists of long rounded ridges having long expanses of brush and open areas. Many parts are tree covered, especially the side slopes of the ridges. Unlike the lower areas, dense stands of aspen fill the draws which lead to the main stream courses. Jeep trails traverse nearly every ridge indicating the ease of travel along the ridge tops.

Scenic/aesthetic value: high
Recreation value: high
Existing recreation developments: none
Major potential recreation uses: hiking, riding, camping

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SUGGESTED GUIDELINES TO MINIMIZE ENVIRONMENTAL DAMAGE

There are some general guidelines and policies that should be incorporated in any effort to minimize environmental damage with respect to oil shale development. The following suggestions are offered as means of protecting the environment, especially in terms of scenic and recreation resources. While these guidelines may overlap into other areas of environmental control, they also are important in considering the recreation and natural beauty aspects in oil shale development. These guidelines are not designed to restrict the development of oil shale resources but rather to complement it.

Environmental management decisions usually affect a wide geographic area. Such is the case with the proposed oil shale development, and collective action on a region-wide basis is indicated. Even carefully determined local and individual decisions usually will not achieve good environmental quality management, nor do the traditional functions of Federal, State and local governments. We suggest that a region-wide authority be formed. It would consider oil shale production and its affects on a region-wide basis. Such an authority should give full and flexible consideration to a wide range of alternatives and implement those alternatives which would achieve a more comprehensive plan of development.

Rules, standards and other techniques for considering environmental quality in oil shale production should be the result of a careful analysis of all affected social and economic values. These considerations should include aesthetics, other resource uses, detrimental effects and the value of the total product. This approach is contrary to the usual approach which is still narrowly focused on individual physical effects and objectives. Thus, the effects and objectives of individual mining operations may or may not be in accord with the total environmental concept.

The economic feasibility of oil shale development must include more than just standard production cost. It should include social and environmental protection cost as well. When all costs are considered, social, environmental and production, there may be a better alternative.

Various means for rehabilitating mining areas should be fully explored, as it may prove to be less costly to rehabilitate than to impose stringent controls on production. To promote rehabilitation, such actions as modifying tax policies might act as an incentive to oil shale producers to accelerate mining technology. This may eventually lead to extraction methods which perhaps would have less massive impact on the environment.

A constant awareness of environmental values should be assured by requiring all lease applicants to submit a plan of mining operations which describes the kind of mining methods to be employed and how the operation will protect recreation and scenic values among other environmental considerations. Protection of environment should be considered in three separate phases of the operation: mining and processing, support operations and site rehabilitation.

A. Mining and Processing

(1) Depending on the type of mining methods employed, an operation plan should include, among other things, the extent of excavation, proposed slopes and grading, drainage plans, number and location of buildings and location of machinery.

(2) An operation plan should show the location of overburden dumps and methods to be used in stockpiling in order to protect existing recreation and scenic values.

(3) Operation plans should prescribe a method for treating and disposing processed shale in order to protect environmental values.

B. Support Operations

(1) A transportation plan should be required which describes, among other things, the type and location of all internal and access roads, railroads, conveyors, and tramways.

(2) The affect of utilities on present and future use of the area for recreation and scenic enjoyment should be considered in all development plans. Examples are the location and treatment of power transmission lines and poles, substations, generators, waterlines, pumping stations, reservoirs and gaslines.

(3) An operation plan should describe planned methods for the treatment and disposal of industrial and municipal waste resulting directly from oil shale mining and processing.

C. Site Restoration

Approval and acceptance of a lease application for oil shale development should be made conditional on the restoration of land to some other purpose. Mining operations should provide some means for restoring dumping sites, abandoned excavations and other mining scars on the landscape. Site restoration techniques could include such things as planting, slope grading, replacement of top soil, stream channel repair, repair of road cuts, developing recreation ponds and reservoirs, creating wildlife areas, producing new grazing lands and eliminating hazards to public safety.

Recreation and scenic values can be destroyed as a result of pollution. Stream quality standards of the Piceance Basin will need to be established and maintained. Similarly, the enforcement and setting of standards concerning air pollution should be accomplished by the establishment of air pollution control basins.

Rural communities in Colorado are generally weak in planning and zoning regulations. Comprehensive plans, in anticipation of required commercial and residential development as the result of shale oil production, should be worked out and necessary zoning and other restrictions be instituted before problems develop.

A set of criteria and standards for the development of oil shale resources should be established at both the state and federal levels. Major objectives should be water quality control, soil stabilization, elimination of hazards to public safety, conservation and preservation of natural resources and scenic values and the restoration of natural beauty.

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Legal controls concerning environmental protective measures and enforcement should be established by the state and federal government. Two examples are conformance and compliance bonds and enforcement regulations.

Finally, recreational and scenic values as well as all other environmental considerations can only receive adequate attention through proper and complete coordination. All levels of government, organizations, and individuals directly concerned with oil shale developments should be kept abreast of all plans and operations relevant to the utilization of oil shale resources.

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E. Possibilities for Environmental Research

Research has two important aspects: (1) bench scale work to define the problems which various pollution sources will present; and (2) field pilot scale activities to design and evaluate measures for prevention and control of such problems. Two sources of pollution have potentially serious problems associated with them and therefore appear to warrant immediate attention. These include handling, placing, storage, and subsequent leaching of burned shales, and the disposal of water chemically and physically bound in the shale, which will be released by the very high temperatures of the retorting process.

1. Disposal of Spent Shales

Burned shale is a potential source of salinity, nutrients, sediment, and organic pollutants. It is a waste which will be produced, regardless of the nature of the retorting operation involved. Bench scale research is necessary in order to determine the kinds and amounts of pollutants which will be leached from the burned shale under various conditions. Even a small fraction of one percent of the mineral, nutrient, organic or trace element content could represent a substantial pollution loading for the receiving water body.

As bench scale studies establish the nature of problems to be expected, pilot scale studies will be required to design and evaluate means for control or prevention of such pollution problems. Investigations should be undertaken to evaluate the influence of the environmental factors upon pollution problems. For example, biological action may either accelerate or retard the leaching of nutrients and organic materials from shale disposal piles.

Although the nature and extent of all problems expected have not been evaluated, preliminary results indicate that leaching of mineral carbonates from the burned shales will occur. Measures for control or elimination of such problems should be designed and evaluated at the earliest possible time. Potential control measures may include modification of burned shale pile geometry; pile sealing or cementing to exclude leaching water; elutriation to remove salts with disposal of elutrient by deep well injection, evaporation or waste water reclamation; reburial of the spent shale. Such activities will require a substantial amount of available spent shale; heavy equipment for material shaping and handling; and expertise in experiment design and evaluation.

2. Disposal of Connate Water in Shale

Shales in the natural state contain water chemically and physically bound into the soil mass, and the very high temperature of the retort process causes this water to be released. Such water, together with water derived from organic materials occurs as a by-product of the retort process.

This water contains a full range of organic and organo-sulfur and nitrogen compounds. These compounds will occur in small quantities. However, they can cause toxicity, color, taste, odor, and utrophication problems even in extremely diluted concentrations. Special care must be taken to avoid such serious potential pollution. For example, organic compounds containing nitrogen and sulfur make up a wide variety of chemicals such as dyes, pesticides, preservatives. Cases are on record where a few pounds of organic pesticides have

contaminated an entire river system. Every effort should be made to evaluate the nature, kinds and concentrations of chemical products produced in the retoriting operation, and to evaluate the water pollution problems which they could cause. Equal effort should be devoted to design and implementation of appropriate disposal techniques such as product recovery, deep well injections, incineration, development of special strains of bacteria adopted to decomposition of retort wastes, etc.

Such research will require a source of waste stream product for research, organic laboratory apparatus and technical skill, and availability of facilities for pilot scale development and evaluation of disposal processes.

Possibilities for Environmental Research (continued)

3. A meteorological study should be made of air movements and and atmospheric patterns in the Piceance Basin, and adjoining areas. Such study is necessary to determine alternate locations of urban facilities as they will relate to industrial sites, as well as the possible flow pattern of air contaminants from the basin.

4. A total environmental research study must be done, which would investigate the interaction of oil shale development with all the ecological processes. The study should look at the effects of development on big and small game; fish; livestock; local communities; ranchers in the area; crops; and the microorganisms that are part of the total ecological community. It would be a broad scaled, cause and effect study, attempting to give us some answers prior to full scale industrial development.

5. An environmental research study should be made into ways of hiding or screening the industrial complex and its structures.

6. Since the amount of spent shale available will be unimaginable, some effort should be put into investigating its uses other than just as a waste. Studies need to be made as to its properties and possible commercial uses.

Research efforts into revegetation of spent shale areas needs to be expanded and intensified.

7. A research investigation should be undertaken into alternative uses of mined areas, especially for recreation purposes. Rehabilitation needs for specific after-mining uses should be identified so as to meet future land use demands.

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Site 1a

F. Livestock:

The Area is located within the Square S Allotment and the public lands have been rated as totalling about 120 animal unit months of forage. Licensees in this allotment, permitted use, and grazing season are:

Name	Number	Season
C. W. Brennan and F. K. Norell	1000 cattle	Spring, Summer, Fall
Burke Bros.	200 cattle	Spring, Summer, Fall
Nellie M. Reagle & Sons	111 cattle	Spring, Summer, Fall

(Note: The permitted use of 1311 cattle is total allowed for the allotment. Numbers were not available for the livestock using this specific Area.)

If this Area was mined using surface strip methods there would probably be no loss of animal unit months to the rancher. A sizeable area within the allotment could be chained to remove the pinyon-juniper overstory, establish forage, and thus make up what would be lost through mining.

(See Overlay No. 2 for the boundary of the Square S Allotment)

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Site 1b

F. Livestock

Area 1b is located within three grazing allotments - Barcus Pinto Gulch Allotment; Indian Spring Allotment; and the Square S Allotment. The public lands are rated as having approximately 269 animal unit months of forage. Licensees by allotment, showing permitted use and grazing season are:

Allotment	Name	Number	Season
Barcus Pinto Gulch	Burke Bros.	343 cattle	Spring, Summer, Fall
Indian Spring	Minford Beard	154 cattle	Spring, Summer, Fall
Square S	C. W. Brennan F. K. Norell	1000 cattle	Spring, Summer, Fall
	Burke Bros.	200 cattle	Spring, Summer, Fall
	Nellie M. Reagle and Sons	111 cattle	Spring, Summer, Fall

(NOTE: The permitted use of 1808 cattle is total allowed for all three allotments. Numbers were not available for the livestock using this specific Area.)

There would probably be no loss of animal unit months if this Area were mined by open pit methods. The loss would possibly be replaced by anticipated pinon-juniper chaining on nearby BLM lands.

(See Overlay No. 2 for the boundaries of the three allotments.)

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Site 1d

F. Livestock

Area 1d is within one grazing allotment - ~~Basus~~ Barcus Pinto Gulch. The land is noted as having approximately 93 animal unit months of forage. Lessees using the allotment, permitted use and grazing season are:

Allotment	Name	Number	Season ~~Spring~~
~~Basus~~ Barcus Pinto Gulch	Burke Bros.	343 cattle	Spring, summer, fall

(Note: The ~~pxmx~~ permitted use of 343 cattle is the total allowed for the allotment. Numbers weren't available for the livestock using this specific Area.)

It would be best to assume that with active mining in the Area, particularly open pit, all 93 animal unit months would be lost to the rancher. There is a possibility that some of the loss could be made up through pinon-juniper chaining, but this hasn't been investigated.

(See Overlay No. 2 for the boundary of this allotment.)

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Site 2a

F. Livestock

Area 2a is within three grazing allotments - Gordon Gulch Allotment; Coyote Gulch Allotment; and Piceance Grazing Unit - Common Use Allotment. The public lands are rated as having approximately 1,278 animal unit months of forage. Licenses by allotment, showing permitted use and grazing season are:

Allotment	Name	Number	Season
Gordon Gulch	Joe Robinson	500 sheep	Spring - Fall
Coyote Gulch	E. Clark Jones	1,330 sheep	Spring - Fall
Piceance Common Use	J. O. Weiland	461 Cattle	Spring, Summer, Fall
	Reuben Oldlands	1,667 Cattle	Spring, Summer, Fall

(Note: The permitted use of 3,958 livestock is the total allowed for all three allotments. Numbers were not available for the livestock using this specific Area.)

If underground mining techniques are used there would probably be little loss of forage. The animal unit months lost would not be replaced.

(See Overlay No. 2 for the boundaries of the three allotments.)

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Site 26

F. Livestock

The Area is within one grazing allotment, The Piceance Grazing Unit - Commun Use Allotment. Public lands are rated as having approximately 1,203 animal unit months of forage. Licensees, showing permitted use and grazing season are shown below:

Piceance Grazing Unit - Common Use Allotment

Name	Number	Season
J. O. Weiland	461 cattle	Spring, Summer, Fall
Reuben Oldlands	1,667 cattle	Spring, Summer, Fall
Gregory C. Berthelson	53 cattle	Spring, Summer, Fall
H. G. Berthelson	587 cattle	Spring, Summer, Fall
Ira C. Johnson	1,066 cattle	Spring, Summer, Fall

(Note: The permitted use of 3,834 livestock is the total allowed for the entire allotment. Numbers were not available for the livestock using this specific Area.)

If underground mining techniques are used, there will probably be little loss of forage. The animal unit months lost would not be replaced.

(See Overlay No. 2 for the boundary of the allotment.)

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Site 2c

F. Livestock

The Area is entirely within the Piceance Grazing Unit-Common Use Allotment. Public lands are rated as having about 1,398 animal unit months of forage. Licensees, showing permitted use and grazing season are listed below:

Piceance Grazing Unit - Common Use Allotment

Name	Number	Season
Reuben Oldlands	1,667 cattle	Spring, Summer, Fall
Gregory C. Berthelson	53 cattle	Spring, Summer, Fall
H.G. Berthelson	587 cattle	Spring, Summer, Fall
Ira C. Johnson	1,066 cattle	Spring, Summer, Fall

(Note: The permitted use of 3,173 livestock is the total allowed for the entire allotment. Numbers were not available for the livestock using this specific Area.)

If underground mining is used there will probably be little loss of forage. The animal unit months lost would not be replaced.

(See Overlay No. 2 for location of this grazing allotment.)

Site 3a

F. Livestock

Area 3a is located within three grazing allotments - Upper Fletcher Draw Allotment; Greasewood Allotment; and Indian Spring Allotment. The public lands within the Area are rated at about ~~1,232~~ 1,347 animal unit months of forage. Licensees by allotment, showing permitted use and grazing season are:

Allotment	Name	Number	Season
Upper Fletcher Draw	Sterling Cook	140 cattle	Spring, summer and fall
Greasewood	Hugh Caldwell	320 cattle	Summer and fall
Indian Spring	Minford Beard	154 cattle	Spring, summer and fall

(Note: The permitted use of 614 cattle is total allowed for all three allotments. Numbers were not available for the livestock using this specific Area.)

The animal unit months would be lost to ranchers using this Area, and there is little opportunity to offset this loss with privileges elsewhere. Surface use of the Area would also deprive ranchers of the use of existing water development.

(See Overlay No. 2 for the boundaries of these three allotments.)

Site 1a

G. Soils:

Shallow rocky and deep moderately dark colored soils of the uplands:

Soil parent materials are mainly limy sandstones and shales along with reworked valley fill derived from sandstone and shale. Much of the fill material is stony or gravelly. Eolian deposits mantle portions of the rolling upland divides between creeks. Recent alluvium is of minor extent. Alluvial valleys have been markedly influenced at many places by sediments and colluvium from nearby slopes.

One of the most extensive components of this Area is the light colored, shallow, stony soils that are intermingled with large sandstone boulders and rock outcrops. They overlie sandstone or shale at depths of less than 20 inches, and are usually calcareous. Stony souls are extensive near narrow valleys and canyons that dissect the Area. At many locations soft sandstone is penetrated by tree roots. Closely associated with rocky soils are deeper soils with weak horizonation that have high proportions of coarse fragments in the subsoil. Deeper soils are in footslope positions below and within the complex patterns of shallow soils.

Medium depth soils occupy lower portions of many narrow mesa divides. They have formed in local wind deposited sandy materials derived for the most part from sandstone. The following profile

is representative of some of the soils that have formed over sandstone in sagebrush openings above juniper covered slopes:

A1 0 to 3 inches, brown (7.5YR 5/3) fine sandy loam, brown (7.5YR 4/3) moist; weak coarse platy structure breaking to moderate very fine granular structure; soft when dry, very friable when moist; noncalcareous; neutral; clear smooth boundary.

AC 3 to 18 inches, brown (7.5YR 5/4) light fine sandy loam, brown (7.5YR 4/4) moist; weak coarse prismatic structure breaking to weak coarse subangular blocky structure; hard when dry, very friable when moist; noncalcareous; neutral; gradual smooth boundary.

C 18 to 24 inches, brown (7.5YR 5/4) light fine sandy loam, brown (7.5YR 4/4) moist; massive; hard when dry, very friable when moist; few soft sandstone chips; non-calcareous; neutral; clear irregular boundary.

R 24 inches and below, light brown (7.5YR 6/4) and reddish yellow (5YR 6/6) rock sandstone which is noncalcareous. Deep, moderately dark colored loamy soils which are noncalcareous to depths of 6 to 24 inches occupy smoother slopes on the divides. Often they have formed in calcareous wind-blown deposits of loamy texture.

The following profile is representative:

A1 0 to 3 inches, brown (7.5 YR 5/2) loam, dark brown (7.5YR 3/2) when moist; weak medium platy structure breaking to moderate fine granular structure; soft when dry, very friable when moist; noncalcareous; mildly alkaline; clear smooth boundary.

B_2t 3 to 10 inches, brown (7.5YR 5/4) light clay loam, brown (7.5YR 4/4) when moist; weak to moderate medium prismatic structure breaking to moderate medium subangular blocky structure; very hard when dry, friable when moist; thin nearly continuous clay films on vertical and horizontal ped faces; noncalcareous; mildly alkaline, clear smooth boundary.

B_3ca 10 to 20 inches, brown (7.5YR 5/4) loam, brown (7.5YR 4/4) moist; weak medium prismatic structure breaking to weak medium subangular blocky structure; hard when dry, friable when moist; very thin patchy clay films chiefly on vertical ped faces, some visible lime in finely divided forms; strongly calcareous; moderately alkaline; gradual smooth boundary.

Cca 20 to 50 inches, light brown (7.5YR 6/4) loam, brown (7.5YR 5/4) moist; weak coarse subangular blocky structure; hard when dry, friable when moist; moderate amounts of visible lime in finely divided forms; strongly calcareous; strongly alkaline.

Site 1b

G. SOILS

SOILS IN AREA 1b ARE OF TWO BASIC TYPES. EXPLANATION OF BOTH FOLLOWS.

(A) SHALLOW, ROCKY AND DEEP MODERATELY DARK COLORED SOILS OF THE UPLANDS:

SOIL PARENT MATERIALS ARE MAINLY LIMY SANDSTONES AND SHALES ALONG WITH REWORKED VALLEY FILL DERIVED FROM SANDSTONE AND SHALE. MUCH OF THE FILL MATERIAL IS STONY OR GRAVELLY. EOLIAN DEPOSITS MANTLE PORTIONS OF THE ROLLING UPLAND DIVIDES BETWEEN CREEKS. RECENT ALLUVIUM IS OF MINOR EXTENT. ALLUVIAL VALLEYS HAVE BEEN MARKEDLY INFLUENCED AT MANY PLACES BY SEDIMENTS AND COLLUVIUM FROM NEARBY SLOPES.

ONE OF THE MOST EXTENSIVE COMPONENTS OF THIS AREA IS THE LIGHT COLORED, SHALLOW, STONY SOILS THAT ARE INTERMINGLED WITH LARGE SANDSTONE BOUNDERS AND ROCK OUTCROPS. THEY OVERLIE SANDSTONE OR SHALE AT DEPTHS OF LESS THAN 20 INCHES, AND ARE USUALLY CALCAREOUS. STONY SOULS ARE EXTENSIVE NEAR NARROW VALLEYS AND CANYONS THAT DISSECT THE AREA. AT MANY LOCATIONS SOFT SANDSTONE IS PENETRATED BY TREE ROOTS. CLOSELY ASSOCIATED WITH ROCKY SOILS ARE DEEPER SOILS WITH WEAK HORIZONATION THAT HAVE HIGH PROPORTIONS OF COARSE FRAGMENTS IN THE SUBSOIL. DEEPER SOILS ARE IN FOOTSLOPE POSITIONS BELOW AND WITHIN THE COMPLEX PATTERNS OF SHALLOW SOILS.

MEDIUM DEPTH SOILS OCCUPY LOWER PORTIONS OF MANY NARROW MESA DIVIDES. THEY HAVE FORMED IN LOCAL WIND DEPOSITED SANDY MATERIALS DERIVED FOR THE MOST PART FROM SANDSTONE. THE FOLLOWING PROFILE IS REPRESENTATIVE OF SOME OF THE SOILS THAT HAVE FORMED OVER SANDSTONE IN SAGEBRUSH OPENINGS ABOVE JUNIPER COVERED SLOPES:

A1 0 to 3 inches, brown (7.5YR 5/3) fine sandy loam, brown (7.5YR 4/3) moist; weak coarse platy structure breaking to moderate very fine granular structure; soft when dry, very friable when moist; noncalcareous; neutral; clear smooth boundary.

AC 3 to 18 inches, brown (7.5YR 5/4) light fine sandy loam, brown (7.5YR 4/4) moist; weak coarse prismatic structure breaking to weak coarse subangular blocky structure; hard when dry, very friable when moist; noncalcareous; neutral; gradual smooth boundary.

C 18 to 24 inches, brown (7.5YR 5/4) light fine sandy loam, brown (7.5YR 4/4) moist; massive; hard when dry, very friable when moist; few soft sandstone chips; non-calcareous; neutral; clear irregular boundary.

R 24 inches and below, light brown (7.5YR 6/4) and reddish yellow (5YR 6/6) rock sandstone which is noncalcareous.

Deep moderately dark colored loamy soils which are noncalcareous to depths of 6 to 24 inches occupy the smoother slopes on the divides. Often they have formed in windblown, calcareous deposits. The following profile is representative:

A1 0 to 3 inches, brown (7.5YR 5/2) loam, dark brown (7.5YR 3/2) when moist; weak medium platy structure breaking to moderate fine granular structure; soft when dry, very friable when moist; noncalcareous; mildly alkaline; clear smooth boundary.

$B_{2}t$ 3 to 10 inches, brown (7.5YR 5/4) light clay loam, brown (7.5YR 4/4) when moist; weak to moderate medium prismatic structure breaking to moderate medium subangular blocky structure; very hard when dry, friable when moist; then nearly continuous clay films on vertical and horizontal ped faces; noncalcareous; mildly alkaline; clear smooth boundary.

$B_{3}ca$ 10 to 20 inches, brown (7.5YR 5/4) loam, brown (7.5YR 4/4) moist; weak medium prismatic structure breaking to weak medium subangular blocky structure; hear when dry, friable when moist; very thin patchy clay films chiefly on vertical ped faces, some visible lime in finely divided forms; strongly calcareous; moderately alkaline; gradual smooth boundary.

Cca 20 to 50 inches, light brown (7.5YR 6/4) loam, brown (7.5YR 5/4) moist; weak coarse subangular blocky structure; hard when dry, friable when moist; moderate amounts of visible lime in finely divided forms; strongly calcareous; strongly alkaline.

(b) Moderately deep and deep, dark colored soils of the uplands:

Parent materials consist of mixed alluvium, colluvium, and outwash deposits along streams and valleys. Gravelly and stony valley fill is extensive along the lower mountain slopes. Parent rocks are chiefly sandstones, quartzites, shales and basalt. They have furnished the source for much reworked material in which soils have formed.

Dominant soils of this unit have dark gray or dark grayish brown surface layers that are high in organic matter content. Surface layers are loamy with loam and sandy loam textures being most common. On steep colluvial slopes coarse fragments from higher lying rock ledges and outcrops are usually scattered over the surface soil. Subsoils are more clayey and may be sandy clay loam to clay in texture. Many subsoils contain gravel, stone, and rock fragments. Lime is usually leached to depths of 40 to 60 inches.

Moderately deep and deep soils are intermingled within this unit. At depths between 20 and 40 inches there is usually sandstone, shale or basalt under moderately deep soils. Deep soils have formed in valley fill and may have dark colored buried soils within the upper four feet of the profile. Some dark surface soils are unusually thick and extend to depths of 20 to 30 inches.

The following profile is representative of these soils.

A1 0 to 8 inches, dark gray (10YR 4/1) loam, black (10YR 2/1) moist, moderate fine granular structure; soft when dry, very friable when moist; noncalcareous; neutral; clear smooth boundary.

B1 8 to 12 inches, grayish brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; slightly hard when dry, friable when moist; thin patchy clay films on vertical and horizontal ped faces; few basalt gravels; noncalcareous; neutral; clear smooth boundary.

B2t 10 to 32 inches, brown (7.5YR 5/3) heavy clay loam, dark brown (7.5YR 4/3) moist; moderate medium prismatic structure breaking to moderate to strong medium angular blocky structure; very hard when dry, friable when moist; upper part of horizon is dark brown (7.5YR 3/2) when moist, on vertical ped faces; medium continuous clay films on vertical and horizontal ped faces; few basalt gravels; noncalcareous; neutral; gradual smooth boundary.

B3 32 TO 46 INCHES, BROWN (7.5YR 5/3) CLAY LOAM, DARK BROWN (7.5YR 4/3) MOIST; WEAK TO MODERATE MEDIUM PRISMATIC STRUCTURE BREAKING TO MEDIUM SUBANGULAR BLOCKY STRUCTURE; VERY HARD WHEN DRY, FRIABLE WHEN MOIST; THIN CONTINUOUS CLAY FILMS CHIEFLY ON VERTICAL PED FACES; FEW BASALT GRAVELS AND ROCK FRAGMENTS; NONCALCAREOUS; NEUTRAL; GRADUAL WAVY BOUNDARY.

C 46 TO 60 INCHES, BROWN (7.5YR 5/3) CLAY LOAM, DARK BROWN (7.5YR 4/3) MOIST; MASSIVE OR WEAK COARSE SUBANGULAR BLOCKY STRUCTURE; HARD WHEN DRY, FRIABLE WHEN MOIST; LESS THAN 15 PERCENT BASALT GRAVEL AND ROCK; NONCALCAREOUS; MILDLY ALKALINE.

Site Id

G. Soils

Soils in the Area are predominantly of one type, shallow rocky and deep moderately dark colored soils of the uplands.

Soil parent materials are mainly limy sandstones and shales along with reworked valley fill derived from sandstone and shale. Much of the fill material is stony or gravelly. Eolian deposits mantle portions of the rolling upland divides between creeks. Recent alluvium is of minor extent. Alluvial valleys have been markedly influenced at many places by sediments and colluvium from nearby slopes.

One of the most extensive components of this Area is the light colored, shallow, stony soils that are intermingled with large sandstone boulders and rock outcrops. They overlie sandstone or shale at depths of less than 20 inches, and are usually calcareous. Stony souls are extensive near narrow valleys and canyons that dissect the Area. At many locations soft sandstone is penetrated by tree roots. Closely associated with rocky soils are deeper soils with weak horizonation that have high proportions of coarse fragments in the subsoil. Deeper soils are in footslope positions below and within the complex patterns of shallow soils.

Medium depth soils occupy lower portions of many narrow mesa divides. They have formed in local wind deposited sandy materials derived for the most part from sandstone. The following profile is representative of some of the soils that have formed over sandstone in sagebrush openings above juniper covered slopes:

A1 0 to 3 inches, brown (7.5YR 5/3) fine sandy loam, brown (7.5YR 4/3) moist; weak coarse platy structure breaking to moderate very fine granular structure; soft when dry, very friable when moist; noncalcareous; neutral; clear smooth boundary.

AC 3 to 18 inches, brown (7.5YR 5/4) light fine sandy loam, brown (7.5YR4/4) moist; weak coarse prismatic structure breaking to weak coarse subangular blocky structure; hard when dry, very friable when moist; noncalcareous; neutral; gradual smooth boundary.

C 18 to 24 inches, brown (7.5YR 5/4) light fine sandy loam, brown 7.5YR 4/4) moist; massive; hard when dry, very friable when moist; few soft sandstone chips; non-calcareous; neutral; clear irregular boundary.

R 24 inches and below, light brown (7.5YR 6/4) and reddish yellow (5YR 6/6) rock sandstone which is noncalcareous.

Deep moderately dark colored loamy soils which are noncalcareous to depths of 6 to 24 inches occupy the smoother slopes on the divides. Often they have formed in windblown, calcareous deposits. The following profile is representative:

A1 0 to 3 inches, brown (7.5YR 5/2) loam, dark brown (7.5YR 3/2) when moist; weak medium platy structure breaking to moderate fine granular structure; soft when dry, very friable when moist; noncalcareous; mildly alkaline; clear smooth boundary.

B_2t 3 to 10 inches, brown (7.5YR 5/4) light clay loam, brown (7.5YR 4/4) when moist; weak to moderate medium prismatic structure breaking to moderate medium subangular blocky structure; very hard when dry, friable when noist; thin nearly continuous clay films on vertical and horizontal ped faces; noncalcareous; mildly alkaline, clear smooth boundary.

B_3ca 10 to 20 inches, brown (7.5YR 5/4) loam, brown (7.5YR 4/4) moist; weak medium prismatic structure breaking to weak medium subangular blocky structure; hard when dry, friable when moist; very thin patchy clay films chiefly on vertical ped faces, some visible lime in finely divided forms; strongly calcareous; moderately alkaline; gradual smooth boundary.

Cca 20 to 50 inches, light brown (7.5YR 6/4) loam, brown (7.5YR 5/4) moist; weak coarse subangular blocky structure; hard when dry, friable when moist; moderate amounts of visible lime in finely divided forms; strongly calcareous; strongly alkaline.

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Site 2a

G. Soils

The soils are moderately deep and deep, dark colored soils of the uplands. Parent materials consist of mixed alluvium, colluvium, and outwash deposits along streams and valleys. Gravelly and stony valley fill is extensive along the lower mountain slopes. Parent rocks are chiefly sandstones, quartzites, shales and basalt. They have furnished the source for much reworked material in which soils have formed.

Dominant soils of this unit have dark gray or dark grayish brown surface layers that are high in organic matter content. Surface layers are loamy with loam and sandy loam textures being most common. On steep colluvial slopes coarse fragments from higher lying rock ledges and outcrops are usually scattered over the surface soil. Subsoils are more clayey and may be sandy clay loam to clay in texture. Many subsoils contain gravel, stone, and rock fragments. Lime is usually leached to depths of 40 to 60 inches.

Moderately deep and deep soils are intermingled within this unit. At depths between 20 and 40 inches there is usually sandstone, shale or basalt under moderately deep soils. Deep soils have formed in valley fill and may have dark colored buried soils within the upper four feet of the profile. Some dark surface soils are unusually thick and extend to depths of 20 to 30 inches.

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The following profile is representative of the soils within the Area:

A1 0 to 8 inches, dark gray (10YR 4/1) loam, black (10YR 2/1) moist, moderate fine granular structure; soft when dry, very friable when moist; noncalcareous; neutral; clear smooth boundary.

B1 8 to 12 inches, grayish brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; slightly hard when dry, friable when moist; thin patchy clay films on vertical and horizontal ped faces; few basalt gravels; noncalcareous; neutral; clear smooth boundary.

B2t 10 to 32 inches, brown (7.5YR 5/3) heavy clay loam, dark brown (7.5YR 4/3) moist; moderate medium prismatic structure breaking to moderate to strong medium angular blocky structure; very hard when dry, friable when moist; upper part of horizon is dark brown (7.5YR 3/2) when moist, on vertical ped faces; medium continuous clay films on vertical and horizontal ped faces; few basalt gravels; noncalcareous; neutral; gradual smooth boundary.

B3 32 to 46 inches, brown (7.5YR 5/3) clay loam, dark brown (7.5YR 4/3) moist; weak to moderate medium prismatic structure breaking to medium subangular blocky structure; very hard when dry, friable when moist; thin continuous clay films chiefly on vertical ped faces; few basalt gravels and rock fragments; noncalcareous; neutral; gradual wavy boundary.

C 46 to 60 inches, brown (7.5YR 5/3) clay loam, dark brown (7.5YR 4/3) moist; massive or weak coarse subangular blocky structure; hard when dry, friable when moist; less than 15 percent basalt gravel and rock; nonclacareous; mildly alkaline.

Site 2b

G. Soils

Soils in the Area are of two basic types. Explanations of both types follow.

1. Shallow rocky and deep moderately dark colored soils of the uplands:

Soil parent materials are mainly limy sandstones and shales along with reworked valley fill derived from sandstone and shale. Much of the fill material is stony or gravelly. Eolian deposits mantle portions of the rolling upland divides between creeks. Recent alluvium is of minor extent. Alluvial valleys have been markedly influenced at many places by sediments and colluvium from nearby slopes.

One of the most extensive components of this Area is the light colored, shallow, stony soils that are intermingled with large sandstone boulders and rock outcrops. They overlie sandstone or shale at depths of less than 20 inches, and are usually calcareous. Stony souls are extensive near narrow valleys and canyons that dissect the Area. At many locations soft sandstone is penetrated by tree roots. Closely associated with rocky soils are deeper soils with weak horizontation that have high proportions of coarse fragments in the subsoil. Deeper soils are in footslope positions below and within the complex patterns of shallow soils.

Medium depth soils occupy lower portions of many narrow mesa divides. They have formed in local wind deposited sandy materials derived for the most part from sandstone. The following profile is representative of some of the soils that have formed over sandstone in sagebrush openings above juniper covered slopes:

A1 0 to 3 inches, brown (7.5Yr 5/3) fine sandy loam, brown (7.5YR 4/3) moist; weak coarse platy structure breaking to moderate very fine granular structure; soft when dry, very friable when moist; noncalcareous; neutral; clear smooth boundary.

AC 3 to 18 inches, brown (7.5YR 5/4) light fine sandy loam, brown (7.5YR r/r) moist; weak coarse prismatic structure breaking to weak coarse subangular blocky structure; hard when dry, very friable when moist; noncalcareous; neutral; gradual smooth boundary.

C 18 to 24 inches, brown (7.5YR 5/4) light fine sandy loam, brown (7.5YR 4/4) moist; massive; hard when dry, very friable when moist; few soft sandstone chips; non-calcareous; neutral; clear irregular boundary.

R 24 inches and below, light brown (7.5YR 6/4) and reddish yellow (5YR 6/6) rock sandstone which is noncalcareous.

Deep moderately colored loamy soils which are non-calcareous to depths of 6 to 24 inches occupy the smoother slopes on the divides. Often they have formed in wind-blown, calcareous deposits. The following profile is representative:

2. Moderately deep and deep, dark colored soils of the uplands:

Parent materials consist of mixed alluvium, colluvium, and outwash deposits along streams and valleys. Gravelly and stony valley fill is extensive along the lower mountain slopes. Parent rocks are chiefly sandstones, quartzites, shales and basalt. They have furnished the source for much reworked material in which soils have formed.

Dominant soils of this unit have dark gray or dark grayish brown surface layers that are high in organic matter content. Surface layers are loamy with loam and sandy loam textures being most common. On steep colluvial slopes coarse fragments from higher lying rock ledges and outcrops are usually scattered over the surface soil. Subsoils are more clayey and may be sandy clay loam to clay in texture. Many subsoils contain gravel, stone, and rock fragments. Lime is usually leached to depts of 40 to 60 inches.

Moderately deep and deep soils are intermingled within this unit. At depts between 20 and 40 inches there is usually sandstone, shale or basalt under moderately deep soils. Deep soils have formed in valley fill and may have dark colored buried soils within the upper four feet of the profile. Some dark surface soils are unusually thick and extend to depts of 20 to 30 inches.

A1 0 to 3 inches, brown (7.5YR 5/2) loam, dark brown (7.5YR 3/2) when moist; weak medium platy structure breaking to moderate fine granular structure; soft when dry, very friable when moist; noncalcareous; mildly alkaline; clear smooth boundary.

B_2t 3 to 10 inches, brown (7.5YR 5/4) light clay loam, brown (7.5YR 4/4) when moist; weak to moderate medium prismatic structure breaking to moderate medium subangular blocky structure; very hard when dry, friable when moist; thin nearly continuous clay films on vertical and horizontal ped faces; noncalcareous; mildly alkaline, clear smooth boundary.

B_3ca 10 to 20 inches, brown (7.5YR 5/4) loam, brown (7.5YR 4/4) moist; weak medium prismatic structure breaking to weak medium subangular blocky structure; hard when dry, friable when moist; very thin patchy clay films chiefly on vertical ped faces, some visible lime in finely divided forms; strongly calcareous; moderately alkaline; gradual smooth boundary.

Cca 20 to 50 inches, light brown (7.5YR 6/4) loam, brown (7.5YR 5/4) moist; weak coarse subangular blocky structure; hard when dry, friable when moist; moderate amounts of visible lime in finely divided forms; strongly calcareous; strongly alkaline.

Site 2c

G. Soils

Soils in the Area are moderately deep and deep, dark colored soils of the uplands. Parent materials consist of mixed alluvium, colluvium, and outwash deposits along streams and valleys. Gravelly and stony valley fill is extensive along the lower mountain slopes. Parent rocks are chiefly sandstones, quartzites, shales and basalt. They have furnished the source for much reworked material in which soils have formed.

Dominant soils of this unit have dark gray or dark grayish brown surface layers that are high in organic matter content. Surface layers are loamy with loam and sandy loam textures being most common. On steep colluvial slopes coarse fragments from higher lying rock ledges and outcrops are usually scattered over the surface soil. Subsoils are more clayey and may be sandy clay loam to caly in texture. Many subsoils contain gravel, stone, and rock fragments. Lime is usually leached to depths of 40 to 60 inches.

Moderately deep and deep soils are intermingled within this unit. At depths between 20 and 40 inches there is usually sandstone, shale or

basalt under moderately deep soils. Deep soils have formed in valley fill and may have dark colored buried soils within the upper four feet of the profile. Some dark surface soils are unusually thick and extend to depths of 20 to 30 inches.

The following profile is representative of these soils:

A1 0 to 8 inches, dark gray (10yr 4/1) loam, black (10YR 2/1)moist, moderate fine granular structure; soft when dry, very friable when moist; noncalcareous; neutral; clear smooth boundary.

B1 8 to 12 inches, grayish brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; slightly hard when dry, friable when moist; thin patchy clay films on vertical and horizontal ped faces; few basalt gravels; noncalcareous; neutral; clear smooth boundary.

B2t 10 to 32 inches, brown (7.5YR 5/3) heavy clay loam, dark brown (7.5YR 4/3)moist; moderate medium prismatic structure breaking to moderate to strong medium angular blocky structure; very hard when dry, friable when moist; upper part of horizon is dark brown (7.5YR 3/2) when moist, on vertical ped faces; medium continuous clay films on vertical and horizontal ped faces; few basalt gravels; noncalcareous; neutral; gradual smooth boundary.

B3 32 to 46 inches, brown (7.5YR 5/3) clay loam, dark brown (7.5YR 4/3) moist; weak to moderate medium prismatic structure breaking to medium subangular blocky structure; very hard when dry, friable when moist; thin continuous clay films chiefly on vertical ped faces; few basalt gravels and rock fragments; noncalcareous; neutral; gradual wavy boundary.

C 46 to 60 inches, brown (7.5YR 5/3) clay loam, dark brown (7.5YR 4/3) moist; massive or weak coarse subangular blocky structure; hard when dry, friable when moist; less than 15 percent basalt gravel and rock; noncalcareous; mildly alkaline.

Site 3a

G. Soils

Soils in the Area are of two basic types. Both are explained below:

Shallow rocky and deep moderately dark colored soils of the uplands:

Soil parent materials are mainly limey sandstones and shales along with reworked valley fill derived from sandstone and shale. Much of the fill material is stony or gravelly. Eolian deposits mantle portions of the rolling upland divides between creeks. Recent alluvium is of minor extent. Alluvial valleys have been markedly influenced at many places by sediments and colluvium from nearby slopes.

One of the most extensive components of this Area is the light colored, shallow, stony soils that are intermingled with large sandstone boulders and rock outcrops. They overlie sandstone or shale at depths of less than 20 inches, and are usually calcareous. Stony soils are extensive near narrow valleys and canyons that dissect the Area. At many locations soft sandstone is penetrated by tree roots. Closely associated with rocky soils are deeper soils with weak horizonation that have high proportions of coarse fragments in the subsoil. Deeper soils are in footslope positions below and within the complex patterns of shallow soils.

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Medium depth soils occupy lower portions of many narrow mesa divides. They have formed in local wind deposited sandy materials derived for the most part from sandstone. The following profile is representative of some of the soils that have formed over sandstone in sagebrush openings above juniper covered slopes:

A1 0 to 3 inches, brown (7.5YR 5/3) fine sandy loam, brown (7.5YR 4/3) moist; weak coarse platy structure breaking to moderate very fine granular structure; soft when dry, very friable when moist; noncalcareous; neutral; clear smooth boundary.

AC 3 to 18 inches, brown (7.5YR 5/4) light fine sandy loam, brown (7.5YR 4/4) moist, weak coarse prismatic structure breaking to weak coarse subangular blocky structure; hard when dry, very friable when moist; noncalcareous; neutral; gradual smooth boundary.

C 18 to 24 inches, brown (7.5YR 5/4) light fine sandy loam, brown (7.5YR 4/4) moist; massive; hard when dry, very friable when moist; few soft sandstone chips; non-calcareous; neutral; clear irregular boundary.

R 24 inches and below, light brown (7.5YR 6/4) and reddish yellow (5YR 6/6) rock sandstone which is noncalcareous.

Deep moderately dark colored loamy soils which are non-calcareous to depths of 6 to 24 inches occupy the smoother slopes on the divides. Often they have formed in windblown, calcareous deposits. The following profile is representative:

A1 0 to 3 inches, brown (7.5YR 5/2) loam, dark brown (7.5YR 3/2) when moist; weak medium platy structure breaking to moderate fine granular structure; soft when dry, very friable when moist; noncalcareous; mildly alkaline; clear smooth boundary.

B_2t 3 to 10 inches, brown (7.5YR 5/4) light clay loam, brown (7.5YR 4/4) when moist; weak to moderate medium prismatic structure breaking to moderate medium subangular blocky structure; very hard when dry, friable when moist; thin nearly continuous clay films on vertical and horizontal ped faces; noncalcareous; mildly alkaline, clear smooth boundary.

B_3ca 10 to 20 inches, brown (7.5YR 5/4) loam, brown (7.5YR 4/4) moist; weak medium prismatic structure breaking to weak medium subangular blocky structure; hard when dry, friable when moist; very thin patchy clay films chiefly on vertical ped faces, some visible lime in finely divided forms; strongly calcareous; moderately alkaline; gradual smooth boundary.

Cca 20 to 50 inches, light brown (7.5YR 6/4) loam, brown (7.5YR 5/4) moist; weak coarse subangular blocky structure; hard when dry, friable when moist; moderate amounts of visible lime in finely divided forms; strongly calcareous; strongly alkaline.

Moderately deep and deep, dark colored soils of the uplands:

Parent materials consist of mixed alluvium, colluvium, and outwash deposits along streams and valleys. Gravelly and stony valley fill is extensive along the lower mountain slopes. Parent rocks are chiefly sandstones, quartzites, shales and basalt. They have

furnished the source for much reworked material in which soils have formed.

Dominant soils of this unit have dark gray or dark grayish brown surface layers that are high in organic matter content. Surface layers are loamy with loam textures being most common. On steep colluvial slopes coarse fragments from higher lying rock ledges and outcrops are usually scattered over the surface soil. Subsoils are more clayey and may be sandy clay loam to clay in texture. Many subsoils contain gravel, stone, and rock fragments. Lime is usually leaced to depths of 40 to 60 inches.

Moderately deep and deep soils are intermingled within this unit. At depths between 20 and 40 inches there is usually sandstone, shale or basalt under moderately deep soils. Deep soils have formed in valley fill and may have dark colored buried soils within the upper four feet of the profile. Some dark surface soils are unusually thick and extend to depths of 20 to 30 inches.

The following profile is representative of these soils:

A1 0 to 8 inches, dary gray (10YR 4/1) loam, black (10YR 2/1) moist, moderate fine

granular structure; soft when dry, very friable when moist; noncalcareous; neutral; clear smooth boundary.

B1 8 to 12 inches, grayish brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; slightly hard when dry, friable when moist; thin patchy clay films on vertical and horizontal ped faces; few basalt gravels; noncalcareous; neutral; clear smooth boundary.

B2t 10 to 32 inches, brown (7.5YR 5/3) heavy clay loam, dark brown (7.5YR 4/3) moist; moderate medium prismatic structure breaking to moderate to strong medium angular blocky structure; very hard when dry, friable when moist; upper part of horizon is dark brown (7.5YR 3/2) when moist, on vertical ped faces; medium continuous clay films on vertical and horizontal ped faces; few basalt gravels; noncalcareous; neutral; gradual smooth boundary.

B3 32 to 46 inches, brown (7.5YR 5/3) clay loam, dark brown (7.5YR 4/3) moist; weak to moderate medium prismatic structure breaking to medium subangular blocky structure; very hard when dry, friable when moist; thin continuous clay films chiefly on vertical ped faces; few basalt gravels and rock fragments; noncalcareous; neutral; gradual wavy boundary.

C 46 to 60 inches, brown (7.5YR 5/3) clay loam, dark brown (7.5YR 4/3) moist; massive or weak coarse subangular blocky structure; hard when dry, friable when moist; less than 15 percent basalt gravel and rock; noncalcareous; mildly alkaline.

Site 1a

H. Watershed:

The 3,404 acres of land in Area 1a form only a small part of the watershed. The Area is part of the White River subbasin, Upper Colorado River Basin. The Bureau of Land Management has classified the Area as having a moderate erosion hazard under present condition and use. However, land disturbance or change in use could drastically alter this classification. Erosion is chiefly confined to rolling upland divides and stream valleys. Water erosion on rocky, gravelly pinyon-juniper slopes is principally along roads and hunting trails. Trails and roads along steep upper slopes have had a striking effect in concentrating runoff water. Deep gullying and destructive bank cutting is visible along all intermittent creeks and head cutting is common on side drains. Summer storms frequently wash out many bridges and creek crossings within this area. Detrimental flood deposits are left on alluvial fans and bottomlands which formerly supported good stands of grass.

Drainage is into Piceance Creek, then to the White River, through the town of Rangely, and eventually into the Colorado River.

Future plans for watershed development include pinyon-juniper chaining in Sections 35 and 36, Township 1 South, Range 98 West.

During a year when precipitation reaches average or better, live water can be found in all the major drainages in the Basin. The

sources for the live water are springs, both developed and undeveloped. Almost all the good flowing springs are at the higher elevation at the head of the drainages.

Stream and channel characteristics vary from the higher elevations to the lower elevations. At the higher elevations banks are sloping with only a few showing rock outcrops. As the elevation changes going down a stream channel, more rock outcrops appear. The stream bottoms are wider but more deeply cut. The presence of active erosion is visible.

Site 1b

H. WATERSHED

THE NEARLY 4,000 ACRES IN THIS AREA FORM BUT A SMALL PORTION OF THE WATERSHED. THE AREA IS PART OF THE WHITE RIVER SUBBASIN, UPPER COLORADO RIVER BASIN. THE BUREAU OF LAND MANAGEMENT HAS CLASSIFIED THE AREA AS HAVING A MODERATE EROSION HAZARD POTENTIAL UNDER PRESENT USE AND CONDITION. LAND DISTURBANCE AND CHANGES IN LAND USE COULD ALTER THIS SITUATION.

EROSION IS CHIEFLY CONFINED TO ROLLING UPLAND DIVIDES AND STREAM VALLEYS. WATER EROSION ON ROCKY, GRAVELLY PINYON-JUNIPER SLOPES IS PRINCIPALLY ALONG ROADS AND HUNTING TRAILS. TRAILS AND ROADS ALONG STEEP UPPER SLOPES HAVE HAD A STRIKING EFFECT IN CONCENTRATING RUNOFF WATER. DEEP GULLYING AND DESTRUCTIVE BANK CUTTING IS VISIBLE ALONG ALL INTERMITTENT CREEKS AND HEAD CUTTING IS COMMON ON SIDE DRAINS. SUMMER STORMS FREQUENTLY WASH OUT MANY BRIDGES AND CREEK CROSSINGS WITHIN THIS AREA. DETRIMENTAL FLOOD DEPOSITS ARE LEFT ON ALLUVIAL FANS AND BOTTOMLANDS WHICH FORMERLY SUPPORTED GOOD STANDS OF GRASS.

DRAINAGE IS INTO LITTLE DUCK CREEK, AND INTO BOX ELDER CREEK AND ITS TRIBUTARIES; THEN TO PICEANCE CREEK; THEN TO THE WHITE RIVER; THROUGH THE TOWN OF RANGELY; AND EVENTUALLY INTO THE COLORADO RIVER.

FUTURE WATERSHED DEVELOPMENTS ANTICIPATED BY THE BUREAU OF LAND MANAGEMENT INCLUDE:

PINON-JUNIPER CHAINING IN SECTIONS 14 AND 23, TOWNSHIP 1 SOUTH, RANGE 99 WEST.

CHECK ~~DONES~~ Dams IN SECTIONS 11, 13 AND 23, TOWNSHIP 1 SOUTH, RANGE 99 WEST.

DURING A YEAR WHEN PRECIPITATION REACHES AVERAGE OR BETTER, LIVE WATER CAN BE FOUND IN ALL THE MAJOR DRAINAGES IN THE BASIN. THE SOURCES FOR LIVE WATER ARE SPRINGS, BOTH DEVELOPED AND UNDEVELOPED. ALMOST ALL

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the good flowing springs are at the higher elevation at the head of the drainages.

Stream and channel characteristics very from the higher elevations to the lower elevations. At the higher elevations banks are sloping with only a few showing rock outcrops. As the elevation changes going down a stream channel, more rock outcrops appear. The stream bottoms are wider but more deeply cut. The presence of active erosion is visible.

Site 1d

H. Watershed

The nearly 3,000 acres in this Area form but a small portion of the total watershed. The Area is part of the White River subbasin, upper ~~Vxtxkxf~~ Colorado River Basin. The Bureau of Land Management has classified the land as having a moderate erosion hazard potential under current use and condition. Land disturbance and changes in land use could alter this situation.

Erosion is chiefly confined to rolling upland divides and stream valleys. Water erosion on rocky, gravelly pinyon-juniper slopes is principally along roads and hunting trails. Trails and roads along steep upper slopes have had a striking effect in concentrating runoff water. Deep gullying and destructive bank cutting is visible along all intermittent creeks and head cutting is common on side drains. Summer storms frequently wash out many bridges and creek crossings within this area. Detrimental flood deposits are left on Alluvial fans and bottomlands which formerly supported good stands of grass.

Drainage is mainly into Little Duck Creek, then into Piceance Creek; to the White River; through the town of Rangely; and eventually into the Colorado River.

BLM anticipates future watershed developments, including:

Pinon-Juniper chaining in Section 33, Township 1 North, Range 98 West.

Check dams in Section 4, Township 1 South, Range 98 West.

During a year when precipitation reaches average or better, live water can be found in all the major drainages in the Basin. The sources for live water in the springs, both developed and undeveloped. Almost all the good flowing springs are at the higher elevation at the head of the drainages.

Stream and channel characteristics vary from the higher elevations to the lower elevations. At the higher elevations banks are sloping with only a few showing rock outcrops. As the elevation changes going down a stream channel, more rock outcrops appear. The stream bottoms are wider but more deeply cut. The presence of active erosion is visible.

Site 2a

H. Watershed

The some 9,800 acres in Area 2a form but a small portion of the watershed. The Area is part of the White River subbasin, Upper Colorado River Basin. BLM has not yet classified the erosion hazard potential for the Area.

Erosion is slight to moderate. Most evident is that in cultivated fields where runoff water has concentrated and resulted in rilling and gullying. Under native cover, erosion has been limited to washing along stock trails and minor gullying along drainageways.

Drainage is north down the major sub-drainages into Piceance Creek; to the White River; through the town of Rangely; and eventually into the Colorado River.

BLM has no immediate plans for watershed development. Long range possibilities could include brush control and erosion control projects.

During a year when precipitation reaches average or better, live water can be found in all the major drainages. The sources for live water are springs, both developed and undeveloped. Almost all the good flowing springs are at the higher elevation at the head of the drainages.

Stream and channel characteristics vary from the higher elevations to the lower elevations. At the higher elevations banks are sloping with only a few showing rock outcrops. As the elevation changes going down a stream channel, more rock outcrops appear. The stream bottoms are wider but more deeply cut. The presence of active erosion is visible.

Site 2b

H. Watershed

The over 11,000 acres in this Area form only a small part of the total watershed. The Area is part of The White River sub-basin, Upper Colorado River Basin. The Bureau of Land Management has not yet classified the Area as to its erosion hazard potential.

Erosion is chiefly confined to rolling upland divides and stream valleys. Water erosion on rocky, gravelly pinyon-juniper slopes is principally along roads and hunting trails. Trails and roads along steep upper slopes have had a striking effect in concentrating runoff water. Deep gullying and destructive bank cutting is visible along all intermittent creeks and head cutting is common on side drains. Summer storms frequently quash out many bridges and creek crossings within this Area. Detrimental flood deposits are left on alluvial fans and bottomlands which formerly supported good stands of grass. Under native cover, erosion has been limited to washing along stock trails and minor gullying along drainageways.

The drainage pattern is north down major sub-drainages into piceance Creek; to the White River; through the town of Rangely; and eventually into the Colorado River.

BLM has no immediate watershed plans in the Area. Long range possibilities could include erosion control and brush control projects.

During a year when precipitation reaches average or better, live water can be found in all the major drainages. The sources for live water in the Area are springs, both developed and undeveloped. Almost all the good flowing springs are at the higher elevation at the head of the drainages.

Stream and channel characteristics vary from the higher elevations to the lower elevations. At the higher elevations banks are sloping with only a few showing rock outcrops. As the elevation changes going down a stream channel, more rock outcrops appear. The stream bottoms are wider but more deeply cut. The presence of active erosion is visible.

Site 2c

H. Watershed

The over 9,500 acres in this Area form only a small part of the total Piceance and White River basins. The Area is in the White River subasin, Upper Colorado River Basin. The Bureau of Land Management has not yet classified this land as to its erosion hazard potential, but other sources say it is slight to moderate. Most evident is that in cultivated fields where runoff water has concentrated and resulted in rilling and gullying. Under native cover, erosion has been limited to washing along stock trails and minor gullying along drainageways.

The drainage pattern is north down major subdrainages into Piceance Creek; then into the White River; through the town of Rangely; and eventually into the Colorado River.

BLM has no immediate watershed plans for the area. Long range possibilities could include erosion control and brush control projects.

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During a year when precipitation reaches average or better, live water can be found in all the major drainages. The sources for live water are springs, both developed and undeveloped. Almost all the good flowing springs are at the higher elevation at the head of the drainages.

Stream and channel characteristics vary from the higher elevations to the lower elevations. At the higher elevations banks are sloping with only a few showing rock outcrops. As the elevation changes going down a stream channel, more rock outcrops appear. The stream bottoms are wider but more deeply cut. The presence of active erosion is visible.

Site 3a

H. Watershed

The nearly 9,000 acres in this Area form but a small portion of the watershed. The Area is part of the White River sub-basin, Upper Colorado River sub-basin. The Bureau of Land Management has classified the Area as having a moderate to slight erosion hazard potential under present use and condition. Changes in land use could alter this situation.

Erosion is chiefly confined to rolling upland divides and stream valleys. Water erosion on rocky, gravelly pinyon-juniper slopes is principally along roads and hunting trails. Trails and roads along steep upper slopes have had a striking effect in concentrating runoff water. Deep gullying and destructive bank cutting is visible along all intermittent creeks, and head cutting is common on side drains. Summer storms frequently wash out many bridges and creek crossings within this area. Detrimental flood deposits are left on alluvial fans and bottomlands which formerly supported good stands of grass.

Drainage into Yellow Creek; then to the White River; through the town of Rangely; and eventually into the Colorado River.

BLM anticipates the following watershed development:

Check dams in Section 28, Township 1 North, Range 99 West.

During a year when precipitation reaches average or better, live water can be found in all the major drainages in the Basin. The sources for

live water are springs, both developed and undeveloped. Almost all the good flowing springs are at the higher elevation at the head of the drainages. The White River runs water year long.

Stream and channel characteristics vary from the higher elevations to the lower elevations. At the higher elevations banks are sloping with only a few showing rock outcrops. As the elevation changes going down a stream channel, more rock outcrops appear. The stream bottoms are wider but more deeply cut. The presence of active erosion is visible. In some cases vertical walls are formed which range from 20 to 75 feet high. These are usually found in the vicinity of Calamity Ridge.

Site 1a

I. Range Improvements:

There are no range improvements of record on the public lands within Area 1a. It is possible that private landowners, particularly the Colorado Department of Game, Fish and Parks, have improvements on their land.

Table #17

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AREA 1 a

MAP KEY	LEGAL DESCRIPTION				PROJECT	PROJECT			COST			DAT
NO.	Tp.	Rg.	Sec.	Subdiv.	NUMBER	NAME	PRACTICE	UNITS	BLM	OTHER	PROGRAM	C

N O N E

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Site 1b

1. RANGE IMPROVEMENTS

THERE IS ONLY ONE RANGE IMPROVEMENT OF RECORD ON THE PUBLIC LANDS WITHIN AREA 1b. THIS IS MANAGEMENT FENCE BUILT IN 1963. DETAILS ARE SHOWN ON THE TABLE FOLLOWING.

IT IS POSSIBLE THAT THE COLORADO DEPARTMENT OF GAME, FISH AND PARKS HAS IMPROVEMENTS ON ITS PATENTED GROUND IN THE AREA. REIMBURSEMENT OF COST OF ANY IMPROVEMENTS WILL HAVE TO BE MADE IF THE IMPROVEMENTS ARE DAMAGED OR MADE UNUSABLE.

(SEE OVERLAY NO. 2 FOR LOCATION OF RANGE IMPROVEMENTS.)

Table #18

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AREA 2-1b

MAP KEY NO.	Tp.	Rg.	Sec.	Subdiv.	PROJECT NUMBER	PROJECT NAME	PRACTICE	UNITS	COST BLM	COST OTHER	PROGRAM	DATE COMP.
1	1S	99W	11	Lots 7 & 8	C1-R-104	Duck Creek G. & F. Allot. Fence	Fence ♀	3.2 Miles	$980	$2,880	Range Improvement	7/2/63

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Site 1d

I. Range Improvements

Only one range ~~imxpxe~~ improvement project of record is found on the Area. This is a tree chaining project completed in 1962. Details are shown on the table following.

This project was completely undertaken by BLM, and reimbursement of project costs would be made to the Bureau.

(See Overlay No. 2 for location of range improvements.)

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Table #19

AREA ~~4~~ 1d

MAP KEY NO.	LEGAL DESCRIPTION				PROJECT NUMBER	PROJECT NAME	PRACTICE		COST			
	Tp.	Rg.	Sec.	Subdiv.				UNITS	BLM	OTHER	PROGRAM	DATE COMP.
2	1 N.	98 W.	33	Lots 1, 2, 3; N½, N½SW¼; NW¼SE¼	C1-R-46	Barcus Tree Chaining	~~?~~ Tree Chaining	1,842 acres	$5,274	None	Soil and Moisture	1-10-62

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Site 2a

I. Range Improvements

There are eleven range improvements of record on public lands in the Area. These are shown on the table following.

There are possibly improvements on the patented land in the Area, and reimbursement would be made to BLM, contributors to Bureau projects, and to private owner.

(See Overlay No. 2 for location of these range improvements.)

~~Table #20~~

TABLE #20

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AREA I 2a

MAP KEY NO.	LEGAL DESCRIPTION				PROJECT NUMBER	PROJECT NAME	PRACTICE	UNITS	COST		PROGRAM	DATE COMP.
	Tp.	Rg.	Sec.	Subdiv.					BLM	OTHER		
9.	3S	95W	16	SE¼SE¼	310	Gordon Gulch Spring No. 1	Spring	1 ea.	$389	$389	Range Improvement	10/5/53
10.	3S	95W	16	E½SE¼	312	Robinson Truck Trail	Trail	3 mi.	-	221	Range Improvement	10/28/5
11.	3S	95W	22	E½	51	Schutte Gulch Truck Trail	Trail	6.5 mi.	-	550	Sec. 4 Permit	1952
12.	3S	95W	28	NE¼NW¼	311	Gordon Gulch Spring No. 2	Spring	1 ea.	-	604	Range Improvement	11/7/53
13.	3S	95W	31	Lot 4	C-1537	No Name Well	Well	1 ea.	304	1,920	Range Improvement	6/20/60
14.	3S	95W	32	SE¼SE¼	3-C-199	Hay Gulch Spring	Spring	1 ea.	190	140	-	10/8/45
15.	3S	95W	34	NE¼NE¼	C1-439	Schutte Gulch Spring	Spring	1 ea.	234	108	Range Improvement	6/21/5
16.	3S	95W	34	SE¼NE¼	1-C-237	Schutte Reservoir #4	Res.	1 ea.	-	232	-	11/9/50
17.	3S	95W	34	NW¼SE¼	306	Schutte Spring #2	Spring	1 ea.	305	305	Range Improvement	8/20/5
18.	3S	95W	35	E½E½SW¼	C1-R-129	Half Moon Fence	Fence	2.9 mi.	505	2,977	Range Improvement	10/2/64
19.	3S	95W	35	SW¼SW¼	305	Half Moon Canyon Spring	Spring	1 ea.	209	209	Range Improvement	8/24/53

Site 2b

I. Range Improvements

There are four range improvements of record on public lands in the Area. These are shown on the table following.

Possibly there are improvements on the patented land as well, and reimbursement would be made to both BLM and its contributors, and to private owners.

(See Overlay No. 2 for locations of these projects and improvements.)

Table # 21

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AREA ~~II~~ 26

MAP KEY NO.	LEGAL DESCRIPTION				PROJECT NUMBER	PROJECT NAME	PRACTICE	UNITS	COST		PROGRAM	DATE COMP.
	Tp.	Rg.	Sec.	Subdiv.					BLM	OTHER		
20.	3S	96W	14	NE$\frac{1}{2}$NW$\frac{1}{4}$	130	(Unknown)	Spring	1 ea.	(Project Completion Report not Available)			
21.	3S	96W	14	SW$\frac{1}{4}$SE$\frac{1}{4}$	C1-R-5	E-W-2 Spring	Spring	1 ea.	$254	$300	Range Improvement	8/11/61
22.	3S	96W	35	SE$\frac{1}{4}$NE$\frac{1}{4}$	1-13	East Stuart Gulch Spring #2	Spring	1 ea.	$58	$149	--	6/1/42
23.	4S	96W	1	NW$\frac{1}{4}$SE$\frac{1}{4}$	1-7	East Stuart Gulch Spring #1	Spring	1 ea.	$58	$149	--	5/25/42

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Site 2c

I Range Improvements

There is only one range improvement of record on the public domain in the Area. It is shown on the table following.

There may be improvements on the private lands and reimbursement must be made to the private owner, as well as to the Bureau and its contributors.

(See Overlay No. 2 for the location of this range improvement project.)

Table #22

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AREA 2c

MAP KEY NO.	LEGAL DESCRIPTION				PROJECT NUMBER	PROJECT NAME	PRACTICE	UNITS	COST			DATE COMP.
	Tp.	Rg.	Sec.	Subdiv.					BLM	OTHER	PROGRAM	
24	4S	97W	2	NE¼NW¼	26	Berthelson Well	Well	1 ea.	(Project Completion Report Not Available)			

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Site 3a

I. Range Improvements

Seven range improvements are on record on the public lands within Area 3a. Details are shown on the following table. Reimbursement to the Bureau of Land Management and contributing ranchers must be made if the land is taken for other uses. (See Overlay No. 2 for location of range improvements.)

Table #23

FOR U. S. GOVERNMENT USE ONLY

AREA 3a

MAP KEY	LEGAL DESCRIPTION				PROJECT	PROJECT			COST			DATE
NO.	Tp.	Rg.	Sec.	Subdiv.	NUMBER	NAME	PRACTICE	UNITS	BLM	OTHER	PROGRAM	COMP.
3	1N	99W	4	SE¼SW¼	1-132	Greasewood Spring #1	Spring	1 ea	$132	$ 20	CCC	9/12/41
4	1N	99W	9 17	NW¼ W½NE¼	C-1-526	E-W-1 Checks	Check dams	6 ea	275	--	Soil & Moisture	6/6/59
5	1N	99W	10	SW¼NW¼	C1-503	Greasewood Well	Well	1 ea	499	1450	Range Improvement	9/12/58
6	1N	99W	16	NE¼SE¼	C1-479	Barcus Well	Well	1 ea	502	2317	Range Improvement	11/3/58
7	1N	99W	21 22	S½S½ SW¼	114	Beard Caldwell Allot. Fence	Fence	(Project Completion Report Not Available)				
8	1N	99W	27 28	W½ SE¼NE¼; NE¼SE¼	82	Upper Barcus Chaining	Tree Chaining	(Project Completion Report Not Available)				

#

Site 1a

J. Encumbrances on the Land:

1. A road right-of-way barely crosses the $NW\frac{1}{4}SW\frac{1}{4}$ of Section 34, Township 1 South, Range 98 West. Although this is patented land (oil shale is reserved to the U. S.), the road crosses public land both to the northeast and southwest.

   The right-of-way was granted to the Colorado Department of Game and Fish in 1954. (Ref. Colorado Land Office file C-09621)

2. A 50-foot right-of-way for construction of a main gas transmission pipeline was granted to the Cascade Natural Gas Corp. in 1966. The pipeline runs through Lots 17, 18, 19, 20 in Section 1; Lots 17, 18, 19, 20 in Section 2; and Lot 12 in Section 3; all in Township 2 South, Range 98 West. The entire pipeline runs for 90 miles. (Ref. Colorado Land Office file C-0123685.)

   Care must be taken not to disturb the road or the pipeline. If disturbance becomes necessary the oil shale leasee must:

   a. relocate the road to BLM specifications and location, at leasees cost.

   b. negotiate with Cascade Natural Gas Corp. to relocate the pipeline to C.N.G.'s satisfaction, at leasees cost.)

   (See Overlay No. 2 for location of encumbrances.

Site 1b

J. ENCUMBRANCES ON THE LAND

1. A SPECIAL LAND USE PERMIT HAS BEEN ISSUED FOR A 40-ACRE TRACT, THE NW$\frac{1}{4}$NE$\frac{1}{4}$, SECTION 14, TOWNSHIP 1 SOUTH, RANGE 99 WEST. (REF: COLORADO LAND OFFICE FILE C-0127866.)

2. THE BUREAU OF MINES HAS A WITHDRAWAL APPLICATION ON THE FOLLOWING LAND:

TOWNSHIP 1 SOUTH, RANGE 99 WEST
SECTION 11 - LOTS 8 THRU 11.
SECTION 12 - S$\frac{1}{2}$S$\frac{1}{2}$.
SECTION 13 - ALL.
SECTION 14 - ALL.

THE APPLICATION COVERS 1,620.20 ACRES. (REF: COLORADO LAND OFFICE FILE C-0128555.)

(SEE OVERLAY NO. 2 FOR LOCATION OF ENCUMBRANCES.)

SITE 1d

J. Encumbrances on the Land

A search of the land office records disclosed no encumbrances on this site.

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Site 2a

J. Encumbrances on the Land

A search of the land office records reveals only one encumbrance on the land.

A right-of-way, 50 feet wide, is granted to the Western Slope Gas Company for construction, operation, and maintenance of an intrastate natural gas transmission pipeline. The pipeline runs through the SE$\frac{1}{4}$ Section 18 and NE$\frac{1}{4}$ Section 19, Township 3 South, Range 95 West. The right-of-way was granted for 50 years, beginning in 1964. (Ref. Colorado Land Office File C-0123311.)

Care must be taken not to disturb the piepline. If disturbance becomes necessary due to mining activity, the oil shale leasee must negotiate with Western Slope Gas Co. to relocate the pipeline to W.S.G.'s satisfaction at leasee's cost.

(See Overlay No. 2 for location of encumbrance.)

J. Encumbrances on the Land

A search of the land office records shows no encumbrances against the public lands in this area.

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SITE 2-c

J. Encumbrances on the Land

A search of the land office records shows no encumbrances against the public lands in this area.

Site 3a

J. Encumbrances on the Land

There are no encumbrances on the land office records which affect this Area.

K. Timber:

There is no commercial timber within this Area. The juniper is cut for posts and poles by local ranchers. Any loss of this resource because of mining would be minimal.

L. Protection:

This Area is protected from fire by BLM crews operating out of Craig, Colorado. Local ranchers do take initial action on fires, as will the staff of the Meeker Office.

No pest control or plant protection work has been undertaken on this Area.

M. Considerations for items to be included in oil shale test leases

1. Air Pollution Control

Any lease issued by the Department of Interior should include a statement requiring the leasee to comply with the State of Colorado's Air Pollution Control Act (Chapter 45, Colorado Session Laws 1966, as amended and changed 1967.)

2. Water Quality Control

Any lease issued by the Department of Interior should include a statement requiring the leasee to comply with the State of Colorado's Water Pollution Control Act (Chapter 44, Colorado Session Laws 1966, as amended and changed 1967). The leasee must also comply with the State of Colorado's Water Quality Standards for the (1)Colorado River Basin; (2)White River Sub-Basin, as appropriate, and any other basin standards that are appropriate.

3. Domestic Sewage Control

Any lease issued by the Department of Interior should include a statement requiring the leasee to comply with the State of Colorado's Rules For Site Location Approval of Residential Septic Tank Systems (Chapter 44, Colorado Session Laws 1966, as amended by Chapter 217, Coloraod Session Laws 1967).

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4. Solid Waste Disposal

Any lease issued by the Department of the Interior should include a statement requiring the leasee to comply with the State of Colorado's Solid Waste Disposal Sites and Facilities Act (Chapter 358, Colorado Session Laws 1967).

5. Mill Tailing Ponds

Any lease issued by the Department of Interior should include a statement requiring the leasee to follow the State of Colorado's Guidelines For The Design, Operation and Maintenance of Mill Tailing Ponds to Prevent Water Pollution (Guidelines compiled and adopted by the Colorado Water Pollution Control Commission.).

6. Land Use Controls

a. Any lease issued by the Department of Interior should include statements requiring the leasee to abide by Rio Blanco County, Colorado land use control regulations as follows:

(1) Rio Blanco County Zoning Resolution and Map (Article 2, Chapter 106, Colorado Revised Statutes 1963, as amended), as adopted March 20, 1967.

(2) Rio Blanco County Subdivision Regulations (Chapter 106, Article 2, Colorado Revised Statutes 1963), adopted March15, 1965.

(3) Rio Blanco County Mobil Home Regulations (Chapter 106, Article II, Colorado Revised Statutes 1963), adopted June 8, 1965.

b. Any lease issued by the Department of Interior should include statements requiring the leasee to abide by local land use control regulations as follows:

(1) Town of Rangely zoning ordinance, and other appropriate controls.

(2) City of Rifle zoning ordinance, subdivision regulations, and other appropriate controls.

7. Utility Lines

A requirement of any oil shale test lease should be that all utility lines - electric, gas, telephone - be placed underground. This eliminates any permanent damage to the surface, and allows for complete and continual use of the surface. This also eliminates the problem of cluttering up open spaces with undesireable poles, wires, etc.

8. Community Development

Even though these are test lease sites, they are expected to be used for a considerable number of years. Also, acquiring a test lease doesn't give the leasee any preference to future production leases. Therefore it should be a requirement of any Department of Interior lease that the leasee shall not locate housing or other urban-type facilities - including stores, gas stations, or consumer oriented shops - on the test lease site. Neither should the Department make residential or urban-area land available elsewhere in the Piceance basin, or on other public lands. The leasee should be required to use existing communities to the fullest extent. This then permits the County and/or communities to control the

development through their land use control regulations. There is certainly no need to have a sprawling, undisciplined, uncoordinated "boom-town" of shacks, trailers, etc. on the public lands, and then have the people living there demand services (schools, roads, sewer, water, telephone, etc.) from the County.

One exception may be granted to this rule. The leasee may want to have a watchman or caretaker on the site at all times, and lease stipulations should be flexible to allow this use.

9. Site Rehabilitation

Test lease requirements must call for a return of the entire lease site to as near as possible the original condition of the land. This would include removal from the site of all leassees structures - buildings, shops, warehouses, industrial complexes, etc. - and grading and revegetating all disturbed areas. (This doesn't mean that open-pit mining areas must be filled in.)

The leasee should be required to propare a site rehabilitation plan prior to undertaking any removal work, and have the plan approved by the Bureau of Land Management. The leasee, working with BLM people, can come up with a workable plan.

10. Replacement of Survey Corners

The test leases should require the leasee to reimburse the Bureau of Land Management for all costs necessary to replace cadastral survey corners obliterated by developments.

11. Range Improvements

The test leases should require the leasee to reimburse the Bureau of Land Management, any private contributors, and owners of range improvements, for those damaged or made unusable by oil shale activity.

12. Encumbrances

The test leases should require the leasee to relocate, at his expense, and to the satisfaction of the permitee, any encumbrances on the land have have been legally permitted by the Bureau of Land Management.

13. Plan of Development

Probably the most important aspect of issuing test oil shale leases is to know what the leasee proposes to do, and how he proposes to go about development.

It should be a requirement of getting a test lease that the leasee submit a Plan of Development to the Bureau of Land Management. The Bureau, along with other interested agencies, both federal and state, would have the chance to review this Plan prior to awarding a lease.

The Plan need not be in any specific detail, but would include the leasee's proposal for the following:

Proposed Plan of Development

1. Type of mining to be used.
2. Kinds and numbers of equipment.
3. Anticipated number of employees.
4. Where and how will employees and their families be housed.
5. Method of disposing of spent shale.
6. Method of air pollution control to be used.
7. Method of water pollution control to be used.
8. Source and amount of industrial water.
9. Anticipated need for access; right-of-way applications; routes.
10. Anticipated need for material sites - sand, gravel, road material.
11. Proposals for other environmental protection - noise, dust, open space, natural beauty, odor.

12. Proposals for disposing of other industrial wastes, and any human and solid wastes occuring in the operation.
13. Whether or not retorting will be done on the lease site. If so, the type of retorting; size of smokestacks, etc.
14. Opportunities for public viewing of operations; guided tours.
15. Ideas for coordination of development with city, county, and state governments - planning, land use controls, local and state involvement.

14. Oil shale test leases need to require the leasee to abide by road construction standards, placement of drainage facilities, and to develop a road maintenance program, agreeable to the Bureau of Land Management. The leasee must work with BLM in bringing about its road development program.

IV.--GEOLOGY AND MINERAL RESOURCES

COLORADO--PICEANCE CREEK BASIN

A. Geology

1. Stratigraphy

a) General

The part of the Piceance Creek Basin being considered for oil-shale test leases is in an area of 1,600 square miles lying between the Colorado and the White Rivers in northwest Colorado. The surface rock in this area is Eocene in age and is generally mapped as two formations.

The Green River Formation.--One-third consists of marlstone and oil shale of varying quality, high in carbonate; the other two-thirds consists of a heterogeneous mixture of clay, shale, mudstone, algal, oolitic and ostracodal limestone, siltstone and very fine to medium-grained well bedded sandstone.

The Wasatch Formation.--(Underlies and intertongues with the Green River Formation). Consists primarily of varicolored claystones and minor amounts of siltstone, lenticular, fine- to coarse-grained sandstone, conglomerate, carbonaceous shales and lignite.

b) Detailed

The major oil-shale-bearing rock unit, the Green River Formation, has been divided into five members in the Piceance Creek Basin. They are, in ascending order:

Douglas Creek Member.--Consists of a heterogeneous mixture of fine-grained to medium-grained sandstone, siltstone, algal, ostracodal, oolitic and molluscan-bearing limestones, clay shales and very minor amounts of oil shale. In general this member forms a series of low step-like benches and has a brown coloration.

Garden Gulch Member.--Consists in great part of fissile clay shales, with minor amounts of siltstone, sandstone, algal, oolitic, and ostracodal limestone, and thin beds of oil shale in the upper part. In general this member forms a steep, smooth, slate-gray slope.

Anvil Points Member.--Consists dominantly of clastics, siltstone, sandstone, and clay shale, with minor amounts of algal, oolitic and ostracodal limestones, and thin beds of oil shale. This member in places is the stratigraphic equivalent of the Douglas Creek, Garden Gulch and the lower part of the Parachute Creek Members.

Parachute Creek Member.--Consists dominantly of marlstone and carbonate-rich oil shale containing varying amounts of organic matter. Interspersed in the upper part of the member are tuff and analcite beds that usually are less than an inch thick but may range up to more than 10 feet in thickness. In the lower part of the member the oil shale may be interbedded with the clay shale of the Garden Gulch or Anvil Points Member, and in the upper part of the member the marlstone may be interbedded with highly contorted tuffaceous siltstone. Saline minerals or evidence of the former presence of saline minerals are found throughout the member. The Parachute Creek Member weathers to steep white slopes or precipitous cliffs.

Evacuation Creek Member.--Consists dominantly of contorted tuffaceous siltstone, and fine-grained to medium-grained poorly bedded sandstone. Contains minor amounts of marlstone and thin beds of oil shale in the lower part. Along the margin of the basin the member forms the rounded slopes capping the precipitous cliffs of the Parachute Creek Member. The Evacuation Creek Member of the Piceance Creek Basin is lithologically similar to, and the stratigraphic equivalent of the lower part of the Uinta Formation of the Uinta Basin.

2. Structure

a) General

The Piceance Creek Basin is in general a large structural downwarp with overall structural relief of 3,500 feet. Dips range from a minimum of ½ degree along the southern margin of the basin to 25 degrees along the northern margin of the basin. A number of high-angle northwest-trending faults are associated with folds subsidiary to the main structural feature. The oil shale is well jointed throughout the basin. The two major joint systems trend to the northeast and the northwest.

b) Folds

Along the general north-dipping southern flank of the Piceance Creek Basin a northwest-trending syncline is centered in Clear Creek and another northwest-trending syncline is centered near the forks of Parachute Creek. These two synclines are separated by a northwest-plunging anticlinal nose that trends along the drainage divide between Roan Creek and Parachute Creek.

In the northern part of the basin a syncline paralleling the northern margin of the basin is centered about two miles west of the intersection of Piceance Creek and the dry fork of Piceance Creek. A few miles southwest of this, in the approximate center of the north half of the basin, is another northwest-trending syncline. Abutting this on the east, lying entirely east of Piceance Creek and extending to the eastern margin of the basin, is the Piceance Creek anticline. A large west-trending syncline is centered along Hunter Creek two miles south of the intersection of Hunter Creek and Piceance Creek.

Three southeast-plunging anticlinal noses interrupt the east-dipping west flank of the Piceance Creek Basin. The northern one that breaches the margin of the basin near the head of Fletchers Gulch is the eastern extension of the Rangely anticline. The other two structures, one breaching the west flank of the basin at the head of Philadelphia Gulch and the other at Cathedral Creek, are tributary features of the Douglas Creek arch, a large anticline that parallels the Piceance Creek Basin on the west.

c) Faults

A number of high-angle normal faults generally occurring in pairs with a downdropped block in the middle are present near the central part of the basin. These faults are associated with and in general parallel the anticlinal flexures. Displacement on these faults may be as much as several hundred feet. Calcite and solid hydrocarbon filling in the fault zone indicate the former passage of fluids through the zone.

d) Joints

Several very extensive joint systems cut the oil-shale sequence. The upper reaches of many of the north-flowing tributaries of Piceance Creek and those draining the southwest flank of the Piceance Creek anticline appear to be joint controlled. The drainages are subparallel and in general strike between N. 20° E. and N. 35° E. A less pronounced joint system is discernible in the direction of the smaller streams that in general flow at 90 degrees into the larger drainages. Little or no separation along the joint plane is noted in cores drilled in areas at some distance from basin edge. However, in the core along many of the joints there are deposits of calcite and a gilsonite-like hydrocarbon that is indicative of the passage of fluids through some of the joints at some time in the past. The amount of separation along the joint plane increases at the surface.

B. Economic Geology

1. Oil Shale

All of the oil shale of possible commercial interest in the Piceance Creek Basin is in the Parachute Creek Member of the Green River Formation. The essentially continuous oil-shale sequence has been separated into an upper and a lower oil zone separated by a lean oil shale or non-oil-shale unit termed "B" groove.

a) Upper Oil-Shale Zone

The upper oil-shale zone at most places in the southern part of the Piceance Creek Basin forms cliffs 400 to 600 feet high that extend from the rounded slope of the sandstone above the Parachute Creek Member to the slope or recess formed by the lean oil shale, marlstone, siltstone, or sandstone in "B" groove. Near the base of the upper oil-shale zone is a series of rich oil-shale beds that weather to a ledge. The ledge is called the "Mahogany Ledge", bounded at the base by "B" groove and at the top by "A" groove--a minor slope or recess formed by lean oil shale or non oil shale. The Mahogany Ledge ranges in thickness from less than 40 feet near the basin margin to more than 200 feet at or near the depositional center. It is considered the minable unit in an underground mining operation at or near the margin of the basin. The average value of the Mahogany Ledge ranges between 13 and 30 gallons of oil per ton. Individual one-foot beds in the ledge assay as much as 80 gallons of oil per ton and the richest five-foot bed assays more than 60 gallons of oil per ton. The Mahogany Ledge in the subsurface is called the Mahogany Zone.

The part of the upper oil-shale zone above the Mahogany Ledge ranges from zero to more than 500 feet in thickness, and has an average value ranging up to 17 gallons of oil per ton. The oil-shale section above the Mahogany Ledge is best developed in and just north of the Naval Oil Shale Reserve. This unit thins and is diluted with thick beds of coarse clastic material to the north and northwest.

b) Lower Oil-Shale Zone

The lower oil-shale zone extends from the base of "B" groove to the top of the Garden Gulch or the Anvil Points Members. It ranges in thickness from a wedge edge at the northwest margin of the basin to more than 1,000 feet near the depositional center of the basin. The average value of the lower oil-shale zone ranges from less than 10 gallons of oil per ton near the margins of the basin to more than 25 gallons of oil per ton near the depositional center of the basin. One-foot samples of oil shale in the lower oil-shale zone assay as much as 90 gallons of oil per ton and rich beds 10 feet thick assay an average of more than 60 gallons of oil per ton. The lower oil-shale zone is the part of the oil-shale section being considered by the AEC and the USBM, and consortium of oil companies for a nuclear fracturing and *in situ* retorting experiment.

2. Sodium Minerals

A number of carbonate, silicate, borosilicate, and sulfate minerals have been identified in the Green River Formation. Probably those of greatest economic significance in the Piceance Creek Basin are analcite ($NaAlSi_2O_6.H_2O$), dawsonite ($NaAl(OH)_2CO_3$), nahcolite ($NaHCo_3$), and halite ($NaCl$). Analcite is quite abundant in the tuffaceous siltstone of the lower part of the Evacuation Creek Member which is the surface rock in most of the Piceance Creek Basin. Analcite in thin stringers and in beds up to and greater than 10 feet thick is interbedded with the oil shale of the upper oil-shale zone. Lesser amounts are also found in the upper part of the lower oil-shale zone. Dawsonite is finely disseminated in the oil shale throughout most of the Parachute Creek Member and the upper part of the Garden Gulch Member. The greatest concentration of dawsonite is in the lower oil-shale zone at or near the depositional center of the Piceance Creek Basin. Nahcolite is also present in much of the Parachute Creek Member. At the outcrop in the southern part of the basin cavity zones filled with calcite in the upper oil-shale zone indicate the former presence of a highly soluble salt, probably nahcolite. The thickest, purest, and most continuous zones of nahcolite are in the lower oil-shale zone in the central part of the Piceance Creek Basin. Interbedded with nahcolite in the lower oil-shale zone are beds of halite. The halite is geographically restricted to a small area in the north-central part of the basin.

In an area of several hundred square miles the water soluble saline minerals in the lower part of the Mahogany Ledge and the upper part of the lower oil-shale zone have been leached by percolating ground water. This leached zone is characterized by vugs, numerous joints, fragmented and re-cemented oil shale, and the zone usually contains large quantities of water.

3. Oil and Gas

More than 150 wells have been drilled for oil and gas in the Piceance Creek Basin. Much of the drilling has been on and adjacent to the Piceance Creek anticline. Oil has been tested in the Douglas Creek Member of the Green River Formation and gas has been tested in the Parachute Creek and Douglas Creek Members of the Green River Formation, the Wasatch Formation, and the upper part of the Mesaverde Formation. The greatest concentration of oil and gas is on the Piceance Creek anticline and on the east flank of the syncline just south of the Piceance Creek anticline. Other concentrations are along Black Sulphur Creek and the middle reaches of Ryans Gulch. Other gas wells are scattered throughout the area south of the southern line of T. 1 S. Pockets of highly inflammable gas were encountered in core holes drilled north of this line.

4. Other minerals

Around the margin of the basin many of the sandstone beds in the Douglas Creek and Anvil Points Members are asphaltic. Some of the thickest and most highly saturated sandstones are in the Petrolite Hills in the northeast part of the basin. Other hydrocarbon deposits are associated with joints and the normal faults in the basin. An earthy solid hydrocarbon fills the fault zone of a fault that parallels the axis of the Piceance Creek anticline. At places joints are filled with a solid hydrocarbon similar to gilsonite. These are thin, limited in length and presumably noncommercial.

C. Geology of Sites

1. Center of basin.--(1,000 or more feet of shale averaging 25 or more gallons of oil per ton. In this area the Mahogany Ledge combines with the lower oil-shale zone to form one continuous rich unit.) Evaluation of the thickness and richness of the oil shale on the sites is based on assays of core only unless otherwise stated. Assays of rotary cuttings of wells drilled for oil and gas give a fair indication of the value of the oil shale but are not considered reliable enough for potential lease site evaluation. Estimates of thickness and value of oil shale and associated minerals is an approximation based on a maximum of one control point on a site or on extrapolation of information from control points in adjacent areas. Unpublished assay information on the Juhan 4-1 core hole used in the site evaluation may be obtained from the U.S. Bureau of Mines in Laramie, Wyo.

a) Site 1A

Thickness of shale averaging 25 or more gallons of oil per ton.

1. 1,050 feet averaging 28 gallons of oil per ton starting from the top of the Mahogany Zone.

2. 270 feet averaging 25 gallons per ton starting at a horizon 1,050 feet below the top of the Mahogany Zone.

Sodium minerals

1. Dawsonite.--630 feet average 10% by weight beginning approximately 675 feet below the top of the Mahogany Zone.

2. Nahcolite:

a.--238 feet averaging 13% by weight beginning 675 feet below the top of the Mahogany Zone.

b.--230 feet averaging 18% by weight beginning 1,000 feet below the top of the Mahogany Zone

Overburden

Overburden on the Mahogany Zone ranges from 800 feet to 1,300 feet. The lowermost 100 feet of overburden consists of oil shale that has an average value of 15 gallons of oil per ton. The remainder consists of low-grade oil shale interbedded with marlstone, siltstone, and sandstone.

Leached zone

The zone from which salines have been leached is about 600 feet thick and begins about 100 feet below the top of the Mahogany Zone.

Structure

The rocks in the area dip N. 15° E. at the rate of 100 feet per mile. A graben that parallels the axis of the Piceance Creek Basin has noticeable displacement on it, at least as far northwest as Ryans Gulch about $\frac{1}{2}$ mile from the east boundary of the site, and may even extend into the northeast part of the site.

Oil and gas

One well, Ohio Oil Co. No. 1 Unit in sec. 34, T. 1 S., R. 98 W., has been drilled on the site. The well drilled to a total depth of 7,800 feet into the upper part of the Mesaverde Formation. Tests of several horizons indicate no oil or gas in commercial quantities.

b) Site 1B

Thickness of shale averaging 25 gallons or more of oil per ton.

1. 1,090 feet averages 26 gallons of oil per ton starting from a horizon 110 feet above the Mahogany Zone.
2. 170 feet averages more than 25 gallons of oil per ton starting from 979 feet below the top of the Mahogany Zone.
3. 50 feet averages more than 25 gallons of oil per ton starting 1,207 feet below the top of the Mahogany Zone.

Sodium minerals

1. Dawsonite.--More than 600 feet contains dawsonite starting at a horizon 572 feet below the top of the Mahogany Zone.
2. Nahcolite.--More than 360 feet averages 7% nahcolite by weight beginning 741 feet below the top of the Mahogany Zone.

Overburden

Overburden on the Mahogany Zone ranges from 900 feet to 1,300 feet. The lowermost 100 feet of overburden consists of oil shale that averages 12 gallons of oil per ton and includes one bed greater than 10 feet thick that averages about 6 gallons of oil per ton.

Leached zone

The zone from which salines have been leached is more than 1,000 feet thick starting near the base of the Mahogany Zone.

Structure

The prospective site is on the west flank of a syncline. In the northern one-third the dip is to the north and northwest, and in the remaining part of the area the dip is to the west, south, and southwest. The rate of dip is about 100 feet per mile. No faults have been noted on the site.

Oil and gas

One well was drilled for oil and gas on the site. It was drilled in sec. 25, T. 1 S., R. 99 W., to a depth of about 8,000 feet in the upper part of the Mesaverde Formation. The well was tested and found to contain no commercial amounts of oil or gas.

c) Site 1D

Thickness of shale averaging 25 or more gallons of oil per ton.

1. 1,300 feet starting at a point 262 feet below the top of the Mahogany Zone.

Sodium minerals

1. Nahcolite.--About 700 feet, starting at a point 635 feet below the top of the Mahogany Zone.
2. Dawsonite.--800 feet starting at a point 595 feet below the top of the Mahogany Zone.

Overburden

Overburden on the Mahogany Zone ranges from 900 to 1,200 feet. The lowermost 90 feet of overburden consists of oil shale that has an average value of 12 gallons of oil per ton, including one zone more than 10 feet thick that averages about 6 gallons of oil per ton.

Leached zone

The zone from which salines have been leached is about 500 feet thick and begins at the base of the Mahogany Zone.

Structure

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The rocks in the area dip N. 10° W. at the rate of 150 feet per mile.

Oil and Gas

The closest well was drilled $\frac{1}{2}$ mile north of the site in sec. 27, T. 1 N., R. 98 W. This well was drilled to a total depth of 3,223 feet into the top of the Wasatch Formation. Tests indicate no zone containing commercial quantities of oil or gas.

2. Near-basin margin.--(50 or more feet of shale averaging 30 or more gallons of oil per ton.) These tracts are near the southern margin of the basin where the lower oil-shale zone is relatively thin and low grade. The minable unit is in the Mahogany Zone. Evaluation of the thickness and richness of the oil shale on the sites is based on assays of core. No core holes were drilled on the sites; estimates of the thickness and value of the oil shale are mostly based on an extrapolation of assays of core from patented and unpatented oil-shale claims to the south of the sites. Amounts of analcite and nahcolite probably total less than 5% by weight. Halite is not present and the amount of dawsonite is not known. Most assay information utilized in the following site evaluations was derived from U.S. Bureau of Mines Reports of Investigation.

a) Site 2A

Thickness and value of oil shale averaging 30 gallons or more of oil per ton in the Mahogany Zone.

Oil shale averaging 30 gallons of oil per ton is 90± feet thick. The thickness on the site probably ranges from 50 feet to more than 120 feet.

Thickness and value of the lower oil-shale zone.

Below the Mahogany Zone under most of the site is an additional 1,500 feet of oil shale that probably averages about 15 gallons of oil per ton. In the northern part of the site this may include two zones 100 feet thick that average 25 gallons of oil per ton.

Overburden

Overburden on the Mahogany Zone ranges from a minimum of 500 feet along Piceance Creek to more than 1,500 feet on the high drainage divides. The lowest 400 feet of the overburden consists of oil shale that averages approximately 14 gallons of oil per ton, including 3 beds more than 5 feet thick that average more than 25 gallons of oil per ton and 2 beds more than 10 feet thick that average less than 10 gallons of oil per ton.

Structure

Rocks in the area dip at the rate of 150 feet per mile. The dip is generally to the north but in the eastern one-third and along the northern margin the dip is to the west.

Oil and gas

A number of wells on the site have tested potentially commercial amounts of oil and gas at a depth of about 3,000 feet in the Douglas Creek Member of the Green River Formation.

b) Site 2B

Thickness and value of oil shale averaging 30 gallons or more of oil per ton in the Mahogany Zone.

The average thickness of shale averaging 30 or more gallons of oil per ton is approximately 90 feet, ranging from a minimum thickness of 60 feet to a maximum thickness of more than 120 feet.

Thickness and value of the lower oil-shale zone.

The lower oil-shale zone is about 1,500 feet thick and in the northern part of the area averages about 15 gallons of oil per ton. Included in the lower zone in the northern part of the area are two units 100 feet thick that probably average 25 gallons of oil per ton.

Overburden

Overburden on the Mahogany Zone ranges from a minimum of 600 feet along Piceance Creek and along the middle fork of Stuart Gulch at the southern boundary of the site, to a maximum of 1,500 feet along the drainage divides. The lowermost 350 feet of the overburden on the Mahogany Zone consists of oil shale that averages about 15 gallons of oil per ton and one bed, more than 10 feet thick, that averages less than 10 gallons of oil per ton.

Structure

In the eastern half of the area the dip is N. 10° W.; in the remainder of the area the dip is to the north. The rate of dip is about 200 feet to the mile.

Oil and Gas

A number of wells on the site have tested potentially commercial amounts of oil and gas at a depth of about 3,000 feet in the Douglas Creek Member of the Green River Formation.

c) Site 2C

Thickness and value of oil shale averaging 30 gallons of oil per ton in the Mahogany Zone.

The average thickness of shale averaging 30 or more gallons of oil per ton is approximately 100 feet and ranges from a minimum of 80 feet to more than 120 feet.

Thickness and value of the lower oil-shale zone.

The lower oil-shale zone averages about 15 gallons of oil per ton and ranges in thickness from a minimum of 1,200 feet in the southern part of the area to a maximum of 1,500 feet in the northern part of the area. In the northern part of the site, 300 feet of section may average 25 gallons of oil per ton.

Overburden

Overburden on the Mahogany Zone ranges from a minimum of 300 feet along East Willow Creek at the southern boundary of the area to a maximum of 1,300 feet along the drainage divides. The lowermost 350 feet of overburden consists of oil shale that averages about 16 gallons of oil per ton, and includes two beds more than 5 feet thick that average more than 25 gallons per ton and one bed more than 10 feet thick that averages less than 10 gallons of oil per ton.

Structure

Rocks in the area dip N. 10° E. at the rate of about 200 feet per mile.

Oil and Gas

Several wells on the site have tested potentially commercial amounts of gas at a depth of about 5,000 feet in the Wasatch Formation.

3. Site that meets neither criterion of 1,000 feet of 25 gallon per ton oil shale or more than 50 feet of 30 or more gallons of oil per ton in the Mahogany Zone.

* Evaluation of the site is based primarily on assays of cuttings of one well drilled on the site and another well 1.5 miles east of the east margin of the site.

Thickness and value of the Mahogany Zone.

Based on assays of the Marathon Oil Co.'s Chevron Government IXD well drilled in sec. 21, T. 1 N., R. 99 W. The Mahogany Zone is 110 feet thick and averages about 17 gallons of oil per ton.

Based on assays of General Petroleum Corp. well 26-25, drilled in sec. 25, T. 1 N., R. 99 W., the Mahogany Zone is 110 feet thick and averages about 18 gallons of oil per ton.

Thickness and value of the lower oil-shale zone.

The lower oil-shale zone is 1,500 feet thick in the Marathon well. About 900 feet of the lower oil-shale zone has an average value of 17 gallons of oil per ton.

The lower oil-shale zone is more than 1,250 feet thick and averages more than 22 gallons of oil per ton in the General Petroleum well. The richest 600 feet of the lower oil-shale zone averages 30 gallons of oil per ton.

Sodium minerals

Sodium minerals are present but information is too sparse to permit any evaluation of thickness and quantity of these minerals.

Overburden

Overburden ranges from a foot to 1,000 feet. In places along the forks of Greasewood Creek as much as 400 feet of the oil-shale section has been eroded, and on the western margin of the site, along Calamity Ridge, the entire oil-shale sequence has been eroded.

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* Usually assays of rotary cuttings are lower than the true value of the shale but this is not invariably true.

Structure

The east end of the Rangely anticline strikes through the southern half of the area. In the northern part of the area rocks dip to the east at the rate of 450 to 600 feet per mile. In the southern part of the area rocks dip S. 45° E. at the rate of 450 to 600 feet per mile.

Oil and Gas

The Marathon well was drilled to a depth of 8,700 feet into the base of the Mesaverde Formation. The well was tested and found to contain no commercial quantities of oil or gas.

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WYOMING

In Wyoming the known resources of oil shale are in the Green River Formation in the Green River Basin, western Sweetwater County. The principal oil-shale bearing units are the Tipton Shale Member and the Wilkins Peak Member of the Green River Formation. In the southern part of the Green River Basin, the only reliable data on oil yield of the oil shale are the assays of cores from a few widely-spaced trona test holes that either penetrated part or all of the Tipton Shale Member. This data indicates that the Tipton Shale Member does not meet the minimum requirement of 650 million barrels in a sequence 50 feet thick that yields 30 gallons of oil per ton. In this area the Tipton is directly overlain by the Wilkins Peak Member, which contains many thick valuable beds of trona, from which soda ash is derived. This area is also within the land grant area of the Union Pacific Railroad, which owns all odd-numbered sections.

In the northern part of the Green River Basin assays of a core hole in sec. 30, T. 23 N., R. 107 W. fall far short of the minimum. Consequently this area must be considered subminimal until additional core data is obtained.

In the Washakie Basin the only information on the value of oil shale are assays of cuttings from oil and gas tests. These indicate that the Laney Shale Member may contain oil shale that would approach 30 gallons per ton in oil yield. However, no assays of cores from this sequence are available, so the indications cannot be confirmed.

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UTAH

In general, the Eocene geology of eastern Utah is similar to the Eocene geology in the Piceance Creek Basin. The oil shale is in an upper and lower oil-shale zone in the Parachute Creek Member of the Green River Formation. The Mahogany Ledge or Zone of Colorado also extends into the Uinta Basin.

Center of basin.--(1,000 or more feet of shale averaging 25 or more gallons per ton.) Available information indicates that the oil shale in the lower oil-shale zone is too lean to meet the basic criteria.

Near-basin margin.--(50 or more feet of shale averaging 30 or more gallons of oil per ton.) The minable unit is the Mahogany Zone. Evaluation of the thickness and richness of the oil shale is based on assays of core. An area of approximately 100 square miles meets the criteria. This encompasses essentially all of T. 10 S., R. 23 E. and T. 10 S., R. 24 E., the center of the east one-half of T. 10 S., R. 22 E., the western one-third of T. 10 S., R. 25 W., the southern tier of sections in T. 9 S., R. 24 E., and the northern tier of sections in T. 11 S., R. 24 E.

The thickness of 30 gallon shale averages about 55 feet and ranges from a minimum of 50 feet to a maximum of slightly more than 70 feet.

Overburden on the Mahogany Ledge ranges from a minimum of zero feet in T. 10 S., R. 25 E. to more than 2,000 feet in T. 10 S., Rs.23 and 24 E., and T. 9 S., R. 24 E.

Covered by Pre 1920 + recent claims ∴ not considered

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GROUND-WATER HYDROLOGY OF THE POTENTIAL OIL SHALE LEASE SITES

Introduction

Mining and retorting oil shale presents two basic water problems. The first is to keep the mine reasonably dry and the second is to supply water for mining and retorting operations. This part of the report describes the hydrology of the northern part of the Piceance Creek basin and estimates the pumpage necessary to keep a mine reasonably dry. No field data were collected specifically for this report, and in general the conclusions and estimates are based on data collected for other studies. Thus, this report is a preliminary evaluation and, no doubt, additional data and analysis will change the estimates and perhaps some of the concepts.

Open pit mines at sites 1a, 1b, 1d, or 3a will produce as much as 60 cfs (cubic feet per second) during the early years of mine development. After 25 years the yield from a mine would decrease to as little as 15 cfs. Mines at sites 2a 2b, or 2c, ~~or 2d~~ will produce as much as 37 cfs during the early years of mine development. After 25 years yield from a mine at one of these sites would decrease to as little as 8.6 cfs. Water produced from sites 1a, 1b, 1d, or 3a will contain from 1,000 to 20,000 milligrams per liter total dissolved solids; the principal constituents being calcium, magnesium, sodium, and bicarbonate. Water from sites 2a 2b, 2c, or 2d will contain from 500 to 2,000 milligrams per liter total dissolved solids, the principal constituents being sodium and bicarbonate.

Geologic Setting

The Green River Formation, which is bedrock in the area and contains the principal aquifers, has been divided into several units based on differences in its ability to store and transmit water (fig. ___). The lower unit (Garden Gulch Member) is composed of marlstone and oil shale and is relatively impermeable. This unit may contain a few fractures, but in general it impedes the movement of water between the Green River Formation and underlying rocks. This unit is as much as 900 feet thick near the center of the basin.

The Parachute Creek Member of the Green River Formation overlies the lowest unit. The Parachute Creek Member is composed principally of oil shale. This member can be divided into four zones of different hydrologic characteristics. The lowest zone is oil shale, but contains beds of saline minerals. This zone is relatively impermeable and probably little fractured. The zone is characterized by high resistivity on electric logs and has been called the high resistivity zone. The characteristic log response is confined to logs from the center of the basin. The absence of this zone from other areas may be due to solution of the saline minerals, or perhaps due to non-deposition of saline minerals.

Table # 24

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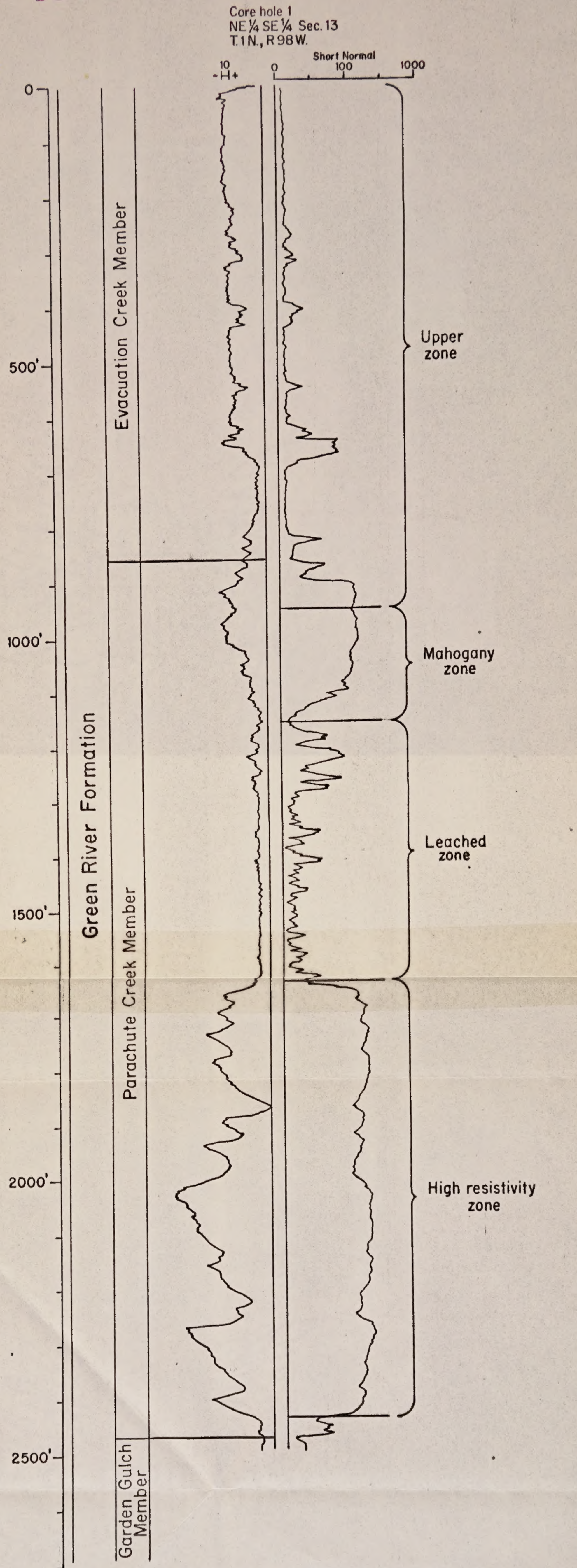


Figure . --Typical electric log from near the center of the basin, showing zones of different hydrologic characteristics.

Overlying the high resistivity zone is a zone characterized by low resistivity on electric logs. Core recovery from this zone is poor, but where core has been recovered it contains voids and very irregular bedding. Fractures are common throughout this zone and wells tapping this zone may yield more than 500 gpm (gallons per minute). Water moving through this zone has dissolved most of the saline minerals, thus increasing the transmissibility and the storage capacities. The zone is called the leached zone. Electric logs throughout the basin characteristically have a zone of low resistivity (fig. ___) and it seems likely that most of the Parachute Creek Member in Rio Blanco County contains the zone. The zone reaches a maximum thickness of ~~500~~ 600 feet near the center of the basin where transmissibility is about 20,000 gallons per day per foot. The leached zone is the most extensive aquifer in the basin.

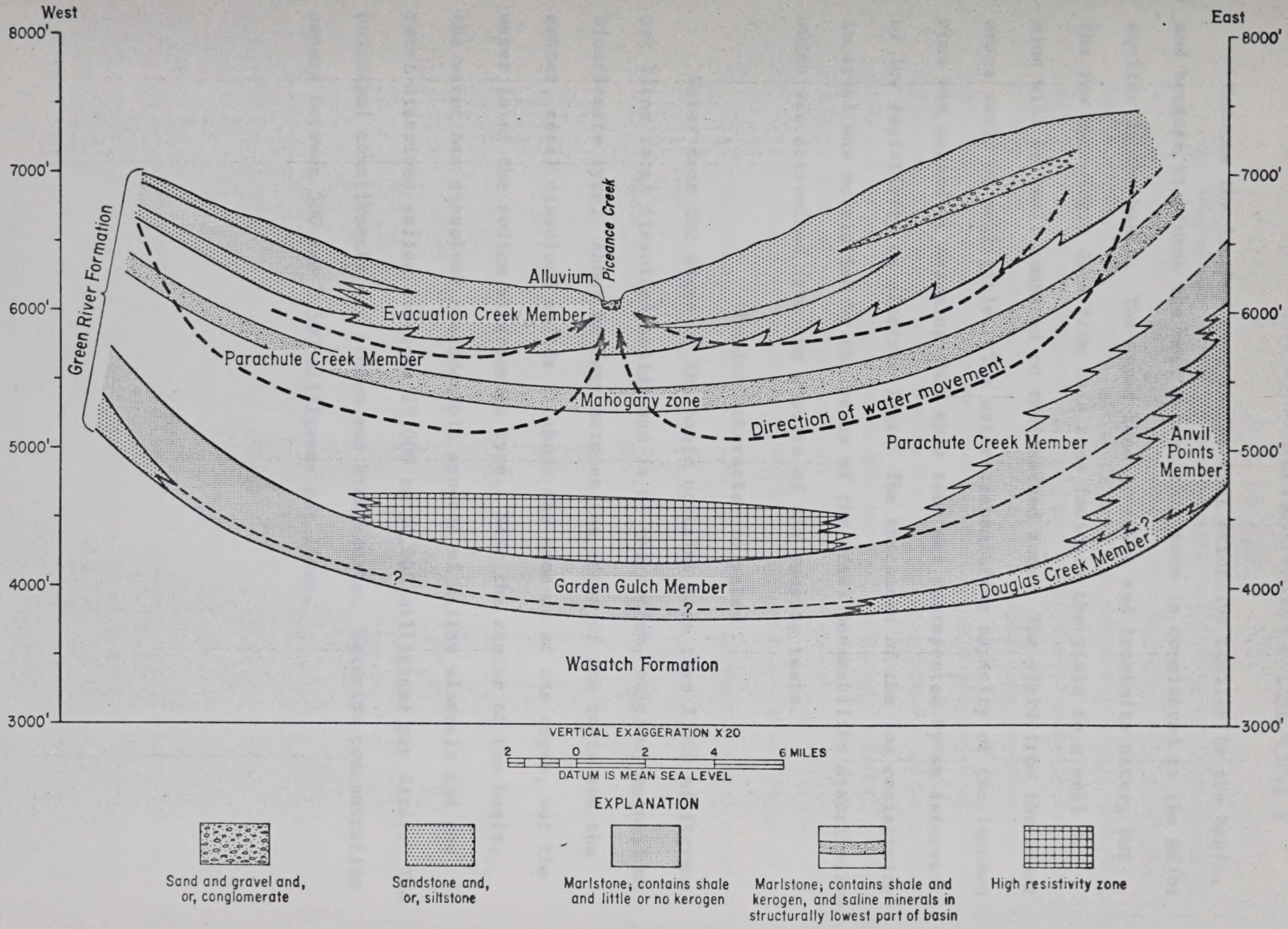
Overlying the leached zone is the Mahogany zone, which is a relatively rich section of oil shale. Saline minerals are not abundant in this zone and apparently were never thickly deposited. The Mahogany is cut by nearly vertical fractures and while the oil shale is relatively impermeable, the fractures allow water to leak through this zone.

Above the Mahogany zone the oil shale grades upward into marlstone and fine-grained sandstone of the Evacuation Creek Member. This upper zone forms the surface rock throughout the basin and the part of the zone topographically higher than the level of the streams is mostly drained. Below stream level the zone is saturated and water moves principally through fractures. Test holes penetrating this zone in the north central part of the basin yield 200 gpm, indicating this zone is less permeable than the leached zone but more permeable than the Mahogany zone. The upper zone ranges from 0 to about 1500 feet thick.

Alluvium along the major streams is probably capable of storing and transmitting more water per unit volume than any other aquifer in the basin. The alluvium is as much as 140 feet thick, but is confined to belts less than a mile wide along the streams and, therefore is of small areal extent compared to the Green River Formation. Because the alluvium has a comparatively small area, it is not capable of supplying large quantities of water to wells for more than a few months.

Hydrologic characteristics of the zones

The regional ground-water movement in the northern part of the basin is from the edges of the basin toward the two major drainages of the basin, Piceance and Yellow creeks. The principal water transmitting zone is the leached zone. Some data indicate that near the edges of the basin the potentiometric head in the leached zone is lower than the head in the upper zone. Near the center of the basin, other data indicate that head in the leached zone is higher than head in the upper zone. These head relations indicate that even though the major direction of flow is toward the center of the basin, there is also vertical flow between zones (fig. ___). Near the edges of the basin, water moves from the upper zone downward through the Mahogany zone into the leached zone. In the center of the basin water moves upward from the leached zone through the Mahogany zone into the upper zone where it is eventually discharged into Piceance or Yellow creeks or is evaporated.



Diagrammatic section across the Piceance Creek basin showing relations of members of Green River Formation.

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Table #25

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Because the leached zone is the most extensive aquifer in the basin, and because it stores the most water, this zone is considered as the major aquifer in the basin. The upper zone contains and transmits water, but the few hydrologic data from this zone indicate the yield to a well or mine will be small compared to the leached zone. The yield from the other zones would be negligible. The water-transmitting capacity of the leached zone was mapped by assuming that this zone was represented by an interval of low resistivity on electric logs. The thickness of the low resistivity interval was multiplied by the value of the areal permeability distribution, which was determined from the results of six pumping tests.

Chemical character of water

Water near the edges of the basin contains less than 2,000 milligrams per liter total dissolved solids and is of the sodium, calcium, magnesium, bicarbonate type. About halfway between the edges of the basin and the center, total dissolved solids is about the same as at the edges, but the water is of the sodium bicarbonate type. Near the center of the basin, the water has dissolved considerable amounts of saline minerals and the total dissolved solids averages 25,000 to 30,000 milligrams per liter. The principal constituents are sodium and bicarbonate. Chloride concentration ranges between 500 and 2,500 milligrams per liter.

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Mine Dewatering

The pumpage necessary to keep a mine reasonably dry was estimated using a computer. Two types of mines were considered -- an open-pit mine that excavates the entire oil shale section and a shaft mine that excavates only 50 feet of the Mahogany zone. The estimates of pumpage are intended to be a first approximation. As more data become available and as mathematical models are developed for the specific physical situation, estimates of pumpage will become more accurate. Because of insufficient data and because of the complex mathematical solution, certain assumptions must be made to solve the problem.

Following are the major assumptions made in the model program:

1. The mines at sites 1a, 1b, 1d, and 3a (open-pit mine) were approximated by squares having side dimensions, 1/2 mile on a side. The mines at sites 2a, 2b, and 2c, [and 2d] (shaft mines) were approximated by circles having a radius of 1 mile and 2 miles.
2. Transmissibility of the aquifer at sites 1a, 1b, 1d, and 3a remains constant until the water level is lowered to the top of the leached zone. Thereafter transmissibility decreases as the water level lowers through the leached zone. The water level remains constant when it reaches the lower half of the zone and the yield decreases.
3. The mines at sites 1a, 1b, 1d, and 3a are instantaneously excavated to the base of the leached zone. Mines at sites 2a, 2b, and 2c, [and 2d] are instantaneously excavated in the Mahogany zone.
4. Coefficient of storage is 0.10.

5. All water pumped from the mine is derived from storage, none being contributed by changes in the recharge-discharge relationships in the basin.

Results of analysis

Estimates based on the above assumptions should represent maximum expectable rates of pumpage required. These estimates will be most in error during the early years when a mine will not be as deep or as areally extensive as assumed.

Estimates of pumpage necessary to dewater the mines and the chemical quality of the pumped water are given in table ___ and the pumping rates are shown in figures ___ and ___. On the basis of the estimates, site 3a would require pumping the least water from an open-pit mine and site~~s~~ 2c and 2d would require pumping the least water from a shaft mine excavating 50 feet of oil shale. The pumpage differs at each site because of differences in the geology and aquifer characteristics. The accuracy of the estimates is probably correct within an order of magnitude, but the estimates are affected by the sparcity of data and the simplifying assumptions.

Table __.--Pumpage necessary to keep mines reasonably dry

Location	Maximum pumping lift (feet)	Pumpage rate (cfs)			Total dissolved solids content of pumped water (mg/1)	Principal Constituents
		1 yr	10 yr	25 yr		
Site 1a	1500	48	31	26	5,000 - 10,000	Sodium, Bicarbonate
1b	1600	39	25	20	1,000 - 2,000	Sodium, Bicarbonate
1d	1500	58	42	36	15,000 - 20,000	Sodium, Bicarbonate
3a	1300	33	18	15	1,000 - 2,000	Calcium, Magnesium, Sodium, Bicarbonate
2a + 2b	800	51	37	25	1,500 - 2,000	Sodium, Bicarbonate
2c	500	20	12	8.6	500 - 1,500	Calcium, Magnesium, Sodium, Bicarbonate
2d	300	20	12	8.6	500 - 1,500	Calcium, Magnesium, Sodium, Bicarbonate

Table # 26

Table #27

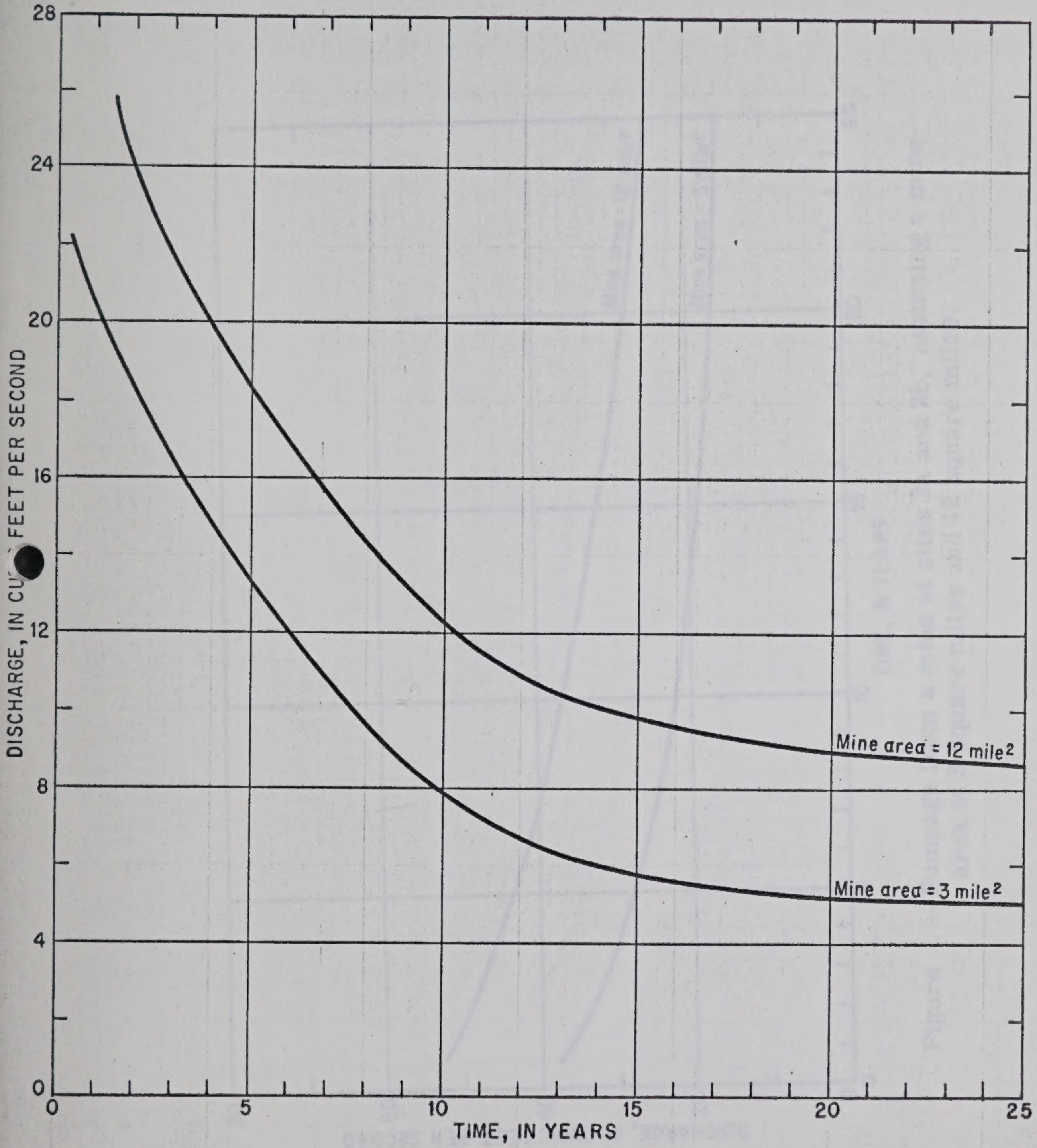

Figure .--Pumpage from a mine at sites 2c and 2d, assuming a mine area of 3 square miles and 12 square miles.

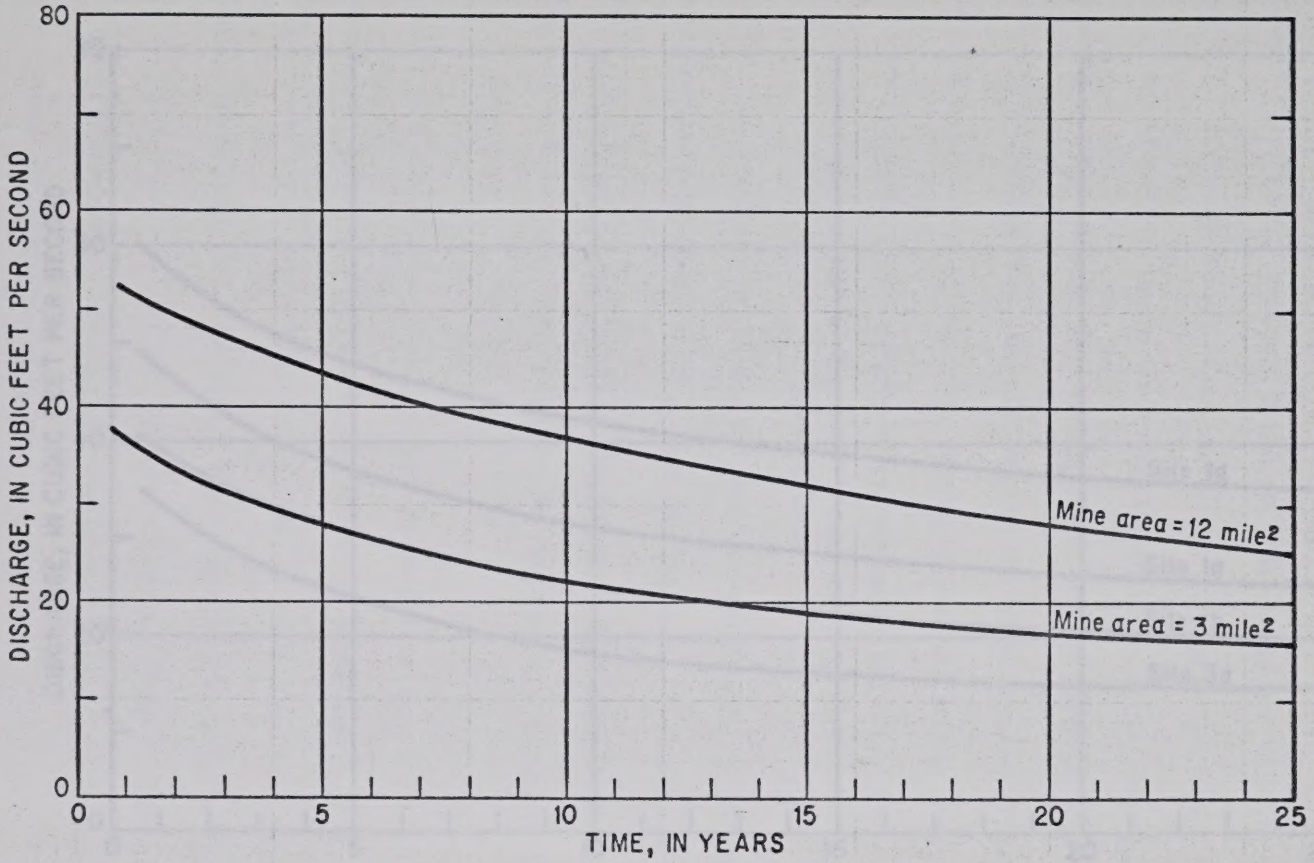

Figure .--Pumpage from a mine at sites 2a and 2b, assuming a mine area of 3 square miles and 12 square miles.

Table #28

Table #29

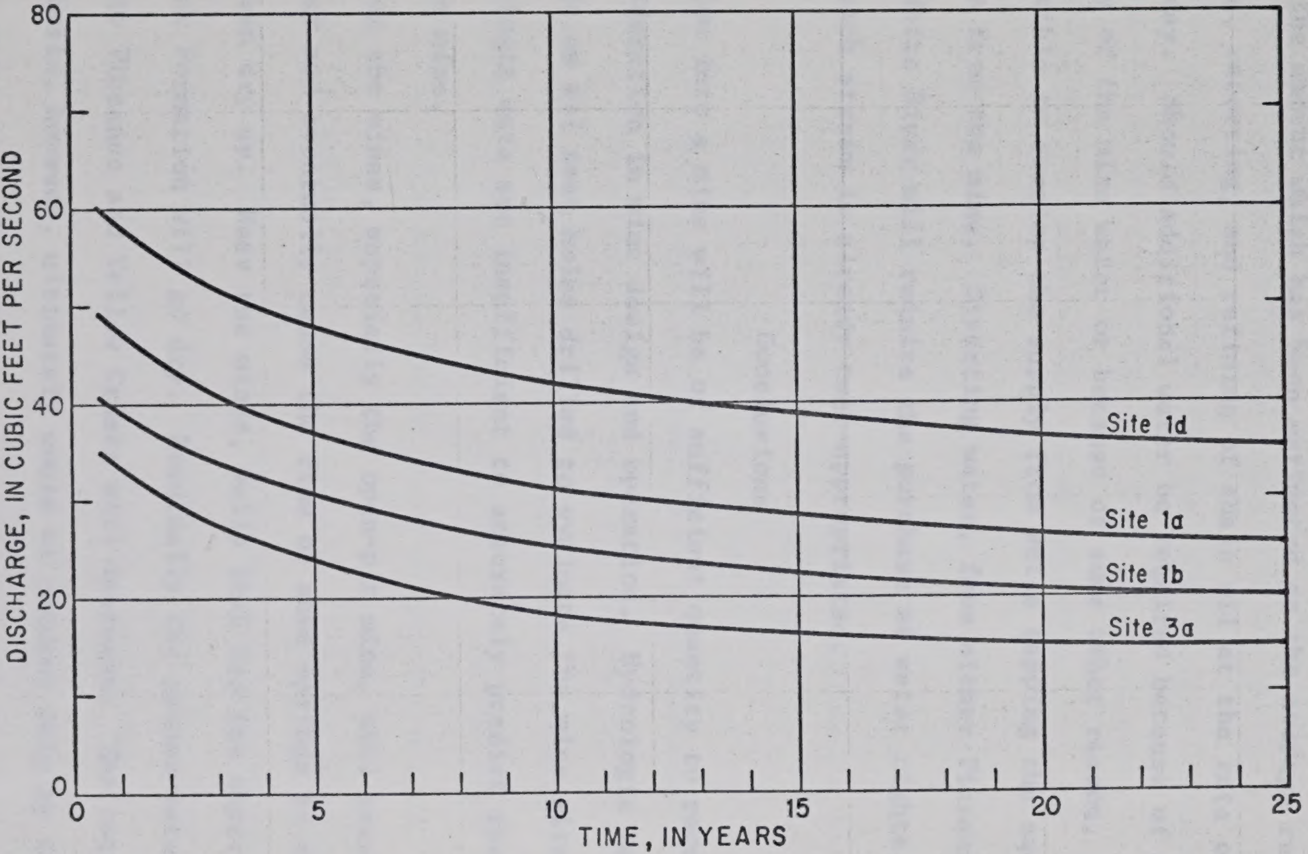

Figure . --Pumpage from an open-pit mine in sites 1a, 1b, 1d, and 3a.

Water Availability

Based on the assumptions used to construct table 1, pumpage to keep the mine dry will be more than ample to supply the 5 to 10 cubic feet per second, the amount which has been estimated as the average requirements in the mining, retorting, and refining of shale oil at the rate of 50,000 barrels per day. Should additional water be required because of chemical unsuitability of the mine water or because of some other reason, it would be possible to develop the supply from wells tapping the aquifer at some distance from the mine. Diverting water, from either Piceance Creek or from the White River will require the purchase of water rights, because, the flow of each stream is already over-appropriated.

Conclusions

Water flow into a mine will be of sufficient quantity to require careful consideration in mine design and operation. Hydrologic tests should be made on all test holes drilled to evaluate the mine site, because present hydrologic data are insufficient to accurately predict the amount of flow into a mine.

Dewatering the mines, especially the open-pit mine, will cause water levels to lower and eventually cause the flow of some springs to decrease and perhaps even dry up. Near the mines, wells that tap the upper zone of the Green River Formation will go dry. Eventually the ground-water contribution to Piceance and Yellow Creeks will decrease. The total water yield of the basin, however, ultimately would be reduced only by the amount of mine water consumptively used.

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V. Mineral Development

A. Likely Mining Method

Both the thick deep oil shale in the center of the Piceance Creek Basin and the thinner richer shale near the periphery can be mined with present mining methods and equipment. Such methods would give a reasonable recovery of the oil shale at costs equal to or less than costs of current large-scale mining operations.

Improvements to the existing technology may be expected as experience is gained in the mining of large tonnages of oil shale. Likewise, new technologies, such as the proposed cut-and-fill system may be developed and perfected with time.

However, today's test leases will have to be mined by today's methods. The two most likely methods are (1) open pit systems for the deep shale beds, 1,000 feet or more thick and averaging about 25 gallons of shale oil per ton and (2) room-and-pillar systems for the shallower beds, 50 feet to 100 feet thick and averaging about 30 gallons per ton.

This part of the report will briefly describe these two methods as applied to mining the test leases, will discuss waste disposal methods, and will make a preliminary evaluation of the leases to rank them from the mining aspect. A third possible method, the cut-and-fill system will be briefly discussed.

1. Open pit systems

Open pit mining is a technically feasible method for recovering oil shale from the tracts in groups 1 and 3. Although detailed pit plans are not within the scope of this report, pencil studies indicate that a mine of the size needed to supply 60,000 tons per calendar day for 20 to 30 years would require a surface area of 800 to 1,000 acres. This is based on a working slope of 2½:1 and a final slope of the pit walls of 1:1. If steeper slopes are found to be stable and safe, then of course the surface area can be reduced with a corresponding saving in the stripping cost. Whatever the final pit design, long-range pit planning will require provisions for sufficient space so that large mining equipment can be operated efficiently and economically.

2. Room-and-pillar systems

Room-and-pillar methods for mining the thinner, 30-gallon shale beds have been developed and tested both by the Bureau of Mines and by private industry. Group 2 tracts could be mined by this method. In a recent report by the Bureau of Mines[1/] such a system was outlined for mining 60,300 tons per calendar day from a shale bed 61 feet thick and averaging 30 gallons of oil per ton of shale. A system of panels was used, with

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[1/] "A Cost Analysis of an Oil Shale Installation in Colorado (Civca 1966)." U. S. Bureau of Mines. Morgantown, W. Va.

panels 1,860 feet long by 1,020 feet wide. Rooms in the panels were 60 feet wide. Pillars for support were 60 feet square. Percent extraction per panel was 68.7.

Because none of the group 2 tracts outcrop, the mine would be developed by vertical and/or inclined shafts. An inclined-conveyor belt might be used to hoist the shale to the surface.

A mine using this system and producing 60,000 tons per calendar day for 20 years would excavate an area of from 2,000 to 2,200 acres.

3. Cut-and-fill systems

A new technology based on the cut-and-fil system and the mechanical excavator or "mole" has been proposed for mining the thick, deep beds.[2]

Such a method would offer advantages over open-pit mining because most of the waste would be back filled into the underground excavations and the ground surface would not be disturbed to any great extent. Research and development would be necessary before the technical and economic feasibility of this method could be established. For this reason, the test tracts would probably not be mined by cut-and-fill methods.

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[2] "Prospects for Oil Shale Development, Colorado, Utah, and Wyoming," May 1968.

B. Handling of Overburden and/or Spent Shale

In open pit mining, about 180,000 tons of material will be moved per day. This is based on a 2:1 stripping ratio (60,000 tons of oil shale and 120,000 tons of overburden). In 20 years of full production, this amounts to about 1.3 billion tons (spent shale and overburden) that must be disposed of in a way that will be safe and not detrimental to the environment.

Surface disposal appears to be the only feasible way of handling this material. It could be stacked in an area of an estimated 1,500 acres. A long range reclamation plan will be required for restoring the land to some form of productive use. This will be provided for in the terms of the lease.

In room-and-pillar mining over 400 million tons of spent shale will be produced in 20 years. If surface disposal is used, about 400 acres will be needed. However, a system of underground waste disposal wherein the spent shale is backfilled into mined-out areas offers several advantages. First, the surface environment would not be disturbed. Second, the backfill would stabilize the underground openings and lessen surface subsidence. Third, some pillar recovery might be possible which would increase the percent extraction. The major disadvantage would be the increased cost of handling the shale twice. But because of its obvious merit, an underground disposal method should be considered.

C. Site evaluation

Preliminary evaluations were made of the sites using the following mining factors: shale reserves, shale thickness, shale grade, depth of overburden, areas for surface waste disposal, and possible ground water problems. Transportation and utility factors were not considered as they appeared to be about the same for all sites.

1. Group 1 sites

Tracts 1-a, 1-b, and 1-d constitute group 1 sites. They lie in the thicker and deeper shale beds amenable to open pit mining methods.

Tract 1-a contains 3,420 acres with a total gross (in place) reserves of about 8 billion barrels. The first tract consists of about 2,470 acres containing 5.8 billion barrels. The second tract, consisting of 950 acres adjoining the first tract, contains 2.2 billion barrels. Tract 1-a was rated excellent on shale reserves, thickness, grade, and depth of overburden, poor on waste disposal and good on ground water.

Tract 1-b, containing 3,820 acres, is the largest tract in group 1. Total gross (in place) reserves are about 9 billion barrels. The first tract, in the eastern part of tract 1-b, consists of about 2,770 acres containing $6\frac{1}{2}$ billion barrels. The second tract, adjacent to the first tract on the west boundary, consists of about 1,070 acres and contains $2\frac{1}{2}$ billion barrels. Tract 1-b was rated excellent on shale reserves, grade, depth of overburden and groundwater, good on shale thickness, and poor on waste disposal.

Tract 1-d, containing 3,200 acres, is the smallest tract in group 1. Total gross (in place) reserves are about 7.4 billion barrels. The first tract, in the southern part of tract 1-d, consists of 2,100 acres and contains about 4.9 billion barrels. The second tract, to the west and adjoining the first tract consists of about 1,100 acres containing about 2.5 billion barrels. Tract 1-d was rated excellent on shale grade and overburden, good on shale thickness and reserves, and poor on waste disposal and ground water.

2. Group 2 sites

Tracts 2-a, 2-b, and 2-c constitute the group 2 sites located in the thinner and richer shale beds amenable to underground mining methods.

Tract 2-a contains 9,720 acres with a total gross (in place) reserve of about 1.8 billion barrels of shale with an average thickness of 90 feet and an average grade of 30 gallons of oil per ton. A bed of thicker and lower grade shale (estimated to be 1500 feet thick with an average grade of 15 gallons per ton) occurs below the higher grade shale bed. Also, within the 1500 feet of low grade shale occur two 100-foot thick zones of shale averaging about 25 gallons per ton. These shale beds were not included in the reserve estimates.

The first tract in the western part of tract 2-a consists of about 7,100 acres containing about 1.3 billion barrels. The second tract, adjoining the first tract on the east, consists of about 2,600 acres containing about $\frac{1}{2}$ billion barrels.

Tract 2-a was rated excellent on shale grade, surface waste disposal and access, and good on reserves, shale thickness, shaft depth, and ground water.

Tract 2b, bordering tract 2-a on the west, is the largest block in group 2, containing 11,280 acres. The shale beds do not outcrop. Gross reserves of 30-gallon shale are estimated at 2.1 billion barrels. Like tract 2-a, this tract also contains thicker, lower grade shales underlying the mahogany ledge which are not included in the reserve estimate.

The first tract in the northern part of tract 2-b consists of 7,800 acres containing about $1\frac{1}{2}$ billion barrels. The second tract adjoins the first tract on the south. It consists of about 3,480 acres and contains about 650 million barrels. If a room-and-pillar mining system were selected, shafts for entry and the 50-acre plant site could be centrally located on the east fork of Stewart Gulch where overburden is thinner and ore and waste handling factors appear favorable. Tract 2-b was rated excellent on shale reserves, grade, waste disposal and access, and good on shale thickness, shaft depth and ground water.

Tract 2-c is slightly smaller than 2-a, containing 9,520 acres with total gross reserves of 30 gallon shale estimated at 1.9 billion barrels. A thicker, low-grade oil shale underlies the mahogany ledge. It is estimated to range from 1,200 feet to 1,500 feet in thickness with an average grade of 15 gallons per ton. One 300-foot thick zone in this horizon may average 25 gallons per ton. This low grade shale is not included in the reserve estimates.

The first tract in the western part of tract 2-c consists of about 6,880 acres containing about 1.4 billion barrels. The second tract, adjoining the first tract on the east, consists of about 2,640 acres containing about ½ billion barrels. Shafts for entry and ore hoisting could be centrally located along East Willow Creek where the overburden is less. Because of the thicker shale bed as compared with tracts 2-a and 2-b, the mine workings would occupy about 200 less acres.

Tract 2-c was rated excellent on shale thickness and grade, shaft depth, waste disposal, and ground water, and good on reserves and access.

3. Group 3 sites

Tract 3-a constitutes the group 3 site. This tract, containing about 10,560 acres, is the largest tract in the Piceance Creek basin, but also contains the lowest grade of shale. Based on drill cuttings from one drill hole in section 21, T1N, R99W, the shale beds should have an

average grade of about 15-20 g/T and an average thickness of about 1200 feet. From this information, we estimate the oil shale reserves as ranging from about 17 billion to 18.8 billion barrels of shale oil. Overburden is thin in some areas and the Mahogany Ledge (considered to be about the top of the thick, continuous, shale section) outcrops along the creeks and gulches draining the area. Despite the lower grade shale, shallow overburden and favorable areas for waste disposal in the canyons to the north and west of tract 3-a contribute toward making this tract a candidate for open pit mining. Before further consideration, however, at least two drill holes should be cored through the oil shale horizon, so that a more accurate reserve estimate can be made.

From the information available, tract 3-a was rated outstanding on shale reserves, overburden, and waste disposal, good on shale thickness and ground water, and poor on shale grade.

D. Retorting

Oil shale, unlike petroleum reservoir rocks, does not contain oil as such. Instead, it contains a solid, organic substance which is readily converted to oil by the application of heat.

Of the many processes which have been proposed for producing oil from shale, three have been operated on scales sufficiently large to demonstrate their feasibility for commercial-scale operation. These processes are all continuous, but they vary in the manner in which the shale is handled and in which heat is transferred to the shale. Neither process requires water. Two of the processes use direct gas to solids heat exchange, and the other was direct solids to solids heat transfer. In each process the shale must be mined, crushed and screened to the desired size before it is charged to the retort. In the Bureau of Mines gas combustion retort approximately 4,500 pounds of average-grade shale must be mined for each barrel of oil produced. In this system about 3,600 pounds of spent shale are discharged for disposal along with about 500 pounds of shale fines which are rejects from the screening operation. For above ground processing there is little preference among the test lease sites.

Another processing technique which is currently receiving much attention but which has not yet been developed on a scale sufficiently large to demonstrate commercial-scale feasibility is in situ retorting. This technique has some advantages over aboveground processing in that

it eliminates the mining, crushing, and screening steps as well as spent shale disposal problems. However, because oil shale is impermeable, permeability must be induced in the shale by some suitable means such as fracturing to allow the hot gases and shale-oil vapors to pass through the shale bed. Heat for the process may be generated either by underground combustion of some of the residual carbon remaining on the spent shale or by burning some of the noncondensible product gases in aboveground equipment. The sites in the thicker shale are more suitable for in situ production, but no site preference is indicated.

SUMMARY AND GENERAL PERSPECTIVE

Preceding sections of this report spell out significant values in resources other than oil shale. Potential damages to these resources are projected as the result of oil shale mining in a basin which remains relatively undisturbed by man's activities. Time and data limitations have not made it possible for the task force to treat the many questions involved definitively. Coordination and editing are incomplete.

Many of the damages which can be anticipated as a result of exploitation of the oil shale resource have been identified. Little effort has been made to measure accurately their effects. Lack of knowledge as to the exact nature of the mining and processing techniques present an incomplete picture.

It is clear that water quality deterioration in the Colorado River Basin is costly to those who use this resource. It is not clear what effects or means of minimization are available for field application since the nature of spoil and spent shale disposal, the volume, quality, and disposal level of groundwater and processing water, and the leaching rates in a disposal environment cannot be predicted. There is little question that viable techniques for pollution control will be identified when other parameters come into focus.

Wildlife habitat contained within the basin is a limiting factor in the life cycle needs of one of the largest mule deer herds in the West. We cannot identify conclusively our abilities to develop substitute wildlife forage or to restore mined lands to suitable habitat.

In spite of the lack of data, knowledge, and techniques there is no necessity for alarm. The magnitude of the oil shale resource is such that mining will have a life span measured in centuries. Technology and economics can produce solutions to the resource damage problems if research and planning are initially incorporated into oil shale utilization. As an example, surface revegetation expenditures of $6,000 per acre supported from the mining of 400 feet of oil shale would add less than ½ cent per ton to overall operational costs.

Mineral conservation was not treated in the body of the report but should be a major consideration in planning oil shale utilization. The state of current mining technology strongly points to open pit mining as the most economic mining system. Open pit mining would result in the greatest utilization of the oil shale resource, since much lower quality oil shale would be processed as a result of very low mining costs in relation to other mining systems. Often alarm is expressed concerning the adverse effects of open pit mining on other resource values. These critical opinions stem from observations of the many past mining operations conducted without regard for their effects on other resource values.

Appropriate planning and economic expenditures can result in restoration of lands mined by open pit methods to a highly productive state. Although the existing terrain and current resource production would be altered considerably, losses would be offset by improvements.

From a total conservation view, tract 3a constitutes the most logical site for initiation of open pit mining within the basin. Attractive development acreage and associated disposal sites free of title conflicts are available. It is envisioned that, with successful application at this site, open pit mining could proceed into the remainder of the basin suited to this system of mining without disturbing additional land not involved directly in mining. With the open pit method, relatively low grade shales can be retorted. Submarginal shale sections would be stockpiled for further developments in technology and economics which can be expected to result in their future utilization.

The group 2 tracts present an important mineral conservation problem. They are the best available tracts without conflicts with pre-1920 mining claims containing high grade oil shale susceptable to underground mining. However, these tracts contain additional thicknesses of lower grade shale ranging from 1200 to 1500 feet averaging 15 gallons per ton which may cause a lessee to consider open pit mining for these tracts. It is certain that as oil shale technology develops these deposits will be adaptable to open pit mining. Should the high grade beds be mined at this time by underground methods only a small percentage of the total resource would be utilized. Future mining of the lower grade shales may never be economic and at best would be less complete.

On the basis of present knowledge it is not practical to specify mining, disposal, restoration or revegetation practices. If it were practical, it would be undesirable since an operator would be "locked in" on practices with little or no motivation for obtaining desired results. It is most desirable to specify objectives and leave room for the operator to innovate the methods of accomplishment. It would be most practical to zero in on these objectives at the time a mining, disposal, and restoration plan is formulated by the mining operator. A group similar to this task force should be formed to identify the desired objectives, review, recommend changes and approve the plans.

Due to the lack of definitive data on restoration and revegetation, initial practices will of necessity be conducted using a basic research approach. Various cooperating governmental agencies should participate and publish results. Close measurement of practices should be maintained. Factors that lead to either success or failure should be thoroughly reported.

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RESOURCE CORRELATION AND PRIORITY RANKING

All potential lease sites were compared in terms of eight major resource considerations, arriving at least priorities from the standpoint of each particular resource interest. These, in turn, are weighted based on relative importance in order to arrive at the site best qualified for oil shale development. Geology and mineability of the various sites were given more weight than other considerations, which include water supply, land status, water pollution, wildlife, recreation and scenic value, and land uses other than recreation and wildlife.

GROUP 1 SITES

Geology

Available geological data indicates the greatest thickness of oil shale in combination with the least overburden occurs on site 1-a, thus making it the most desirable site, followed in order by site 1-b and site 1-d.

Mining

Considering an open pit mining operation, based on the above geologic information and the size of the sites involved, the same order of desirability would be applicable. Underground mining was not considered because of the imperfect knowledge of technology in mining under the conditions of these sites.

Water Supply

Site 1-b would have less surplus pumped water to disperse and would have better quality water than site 1-a and 1-d. Water from site 1-d is very saline. The lift at all three sites is about the same. The order of priority is 1-b, 1-a and 1-d.

Water Pollution

From a water quality management standpoint, site 1-b is slightly more desirable than site 1-a, but both are considerably more desirable than site 1-d.

Land Status

Sites 1-a and 1-b have minor amounts of land free of recent mining claims. However, these same two sites have lands for which the surface is patented. No obvious choice can be made of the three sites on the basis of land status.

Wildlife

Toward the objective of minimizing the impact of shale oil development on wildlife factors, selection of lease site 1-a is given considerable preference over site 1-d; however, both sites 1-a and 1-d are preferred over site 1-b.

Recreation and Scenic Values

Concerning scenic and recreation values the least impact from oil shale development would occur to site 1-d, followed by site 1-b and 1-a.

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Land Uses other than Recreation and Wildlife

Considering other land uses, largely limited to ranch operations, site 1-d rates above the other two, with sites 1-a and 1-b rated about equal.

Conclusion

Based on the above findings, we recommend that Group 1 sites be considered for oil shale leasing in the following order:

FIRST PRIORITY: 1-a
SECOND PRIORITY: 1-b
THIRD PRIORITY: 1-d

GROUP 2 SITES

Geology

In evaluating these three areas, heaviest weight has been given to the geological factors - thickness and value of oil shale formations, and the thickness of overburden. Only a very slight difference occurs between the three sites. However, based on these criteria, site 2-c is slightly preferable to 2-b; 2-b being slightly better than 2-a.

Mining

The mineability of the three tracts was judged on the depth of shafts and surface waste disposal areas. Assumption is made that either the room-and-pillar or cut-and-fill method of underground mining will be used. The order of preference gives equal recommendation to 2-b and 2-c; with 2-a rated slightly behind them.

Water Supply

Two factors were considered in evaluating these areas for oil shale mining purposes - maximum pumping lift and mineral quality of the supply. These criteria show site 2-c far in front of the others. 2-b and 2-a are on an equal basis. On all sites there is an adequate supply of water for oil shale production.

Water Pollution

Factors considered in evaluating water pollution hazards were the degree of disturbance of saline formations in the overburden and oil shale horizons; availability of natural sites for disposal of retorted shales; and the amount of physical and economic detriments caused by the need for disposal of surplus ground waters. The order of preference is 2-a, 2-c and 2-b. The differences among the three sites is very small.

Land Status

Main consideration is given to tracts unencumbered by recent mining claims. Site 2-b is slightly preferable. No choice can be made between 2-a and 2-c on the basis of status.

Wildlife

Three criteria were used in evaluating the wildlife situation - migratory patterns, habitat disturbance and harvest. These indicate that 2-a and 2-b are significantly superior to 2-c, with site 2-a ranking slightly better than 2-b.

Recreation and Scenic Values

Considering recreation and scenic values, the least impact from oil shale development would occur on site 2-a. 2-b is rated next. Most damaging impact to recreation and scenic values occurs on site 2-c.

Land Uses other than Recreation and Wildlife

Major criteria used to evaluate these tracts were size of area, public access routes, number of familes depending on the area, livestock forage and replacement values of range improvements and encumberances. Site 2-b is slightly more desirable than 2-a; 2-c is lowest priority.

Conclusion

Evaluation of all factors indicates a slight preference for oil shale development of site 2-b over site 2-c. Site 2-a is most deficient in the vital factors of geology and mining, and accordingly rated as a third choice.

PRIORITY RANKING

2-b
2-c
2-a

SITE 3-a

Geology

A. Thickness of Shale

More than 1,500 feet of section contains oil shale of possible interest.

B. Value of Shale

No reliable information upon which to base reserve estimates. Information that is available indicates that the value of the shale in much of the area is submarginal with respect to the criteria used in the evaluation of the other sites.

C. Overburden

Most favorable of all sites being considered - ranges from o to a maximum of 1,000 feet and probably averages less than 600 feet.

D. Salines

Contains less than sites in category 1 but slightly more than category 2.

E. Structure

Dip is steeper than on any of the other proposed sites. May be minor faulting in trail canyon.

F. Oil and Gas

No tests of commercial quantities of oil and gas within miles of the site.

Mining and Access

A. Oil shale reserves could be as high as 17 to 18 billion barrels, but no accurate estimate is possible without core drilling.

B. Overburden is thin or non-existent in large areas where the shale outcrops. Stripping ratio would be low, and hence, mining costs would be lower than in any other tract.

C. Oil shale is in a thick minable section with some interbedded layers of sandstone.

D. Access is not a problem. The topography should not present any difficulties to road, pipeline and power construction. Site is about 20 miles south and west of Colorado Highway 64 which connects the towns of Meeker and Rangely.

Water Supply

Much less water problem than would be encountered in other sites. There would be slightly less lift than in Area 1, but much more lift than in Area 2. Only as site 2-c is the quality of water better than, and the amount of pumped surface water less than, as site 3-a.

Water Pollution

Less pollution than in number 1 category sites, slightly more pollution than number 2 category sites.

Land Status

Rates highest of all sites in all categories.

Wildlife

Would have equal preference to number 2 tracts, and greater preference over number 1 tracts.

Recreation and Scenic Values

More attractive for recreation purposes than the number 1 category sites and slightly less attractive than the number 2 sites.

Land Uses other than Recreation and Wildlife

Evaluating current land uses, including area size, public access, disruption of dependent ranch familes, loss of livestock forage, and replacement of range improvements and encumberances, this site should cause less disruption than other sites.

Conclusion

To summarize, site 3-a is noted outstanding in the factors of status and mining when compared with Group 1 and 2 sites. One major factor that might rule against the selection of this site is the lack of reliable information on the value of the oil shale. This site should present less water problems than the other sites. Water pollution should be less than in Group 1 sites and slightly more than in Group 2 sites. It should have the same impact on wildlife as Group 2 sites and less impact than Group 1 sites. It should have more impact than Group 2 sites. On the basis of current land use, site 3-a would be less disruptive to land uses than either Groups 1 or 2.

Recommendation

In order to arrive at a decision for this tract, it is recommended that core holes be drilled. This site is recommended over the Group 1 sites if it is determined that the quality of oil shale is adequate to meet industry's needs. The most advantageous locations for core drill holes are:

1. NE¼, NE¼, SW¼ Section 34, T. 1 N., R. 99 W.
2. NE¼, SW¼, SE¼ Section 33, T. 2 N., R. 99 W.

APPENDIX #3

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UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SOLICITOR
DENVER REGIONAL OFFICE
ROOM 1400, BUILDING 67
DENVER FEDERAL CENTER
DENVER, COLORADO 80225

AUG 9 1968

Memorandum

To: Lewis Chichester, Building 50, Division of S&T, Denver Service Center, Bureau of Land Management

From: Regional Solicitor, Denver

Subject: Evaluation report on potential sites for oil shale leases

Pursuant to your recent telephone request, we are submitting the following for possible inclusion in the report being written on the evaluation of potential sites for oil shale leases.

> A question has arisen as to whether recently located mining claims, which are of questionable validity, but nevertheless create a cloud on the title to the lands, can properly be ignored in the issuance of test leases in view of the Act of August 13, 1954, 68 Stat. 708, et seq., 30 U.S.C. 521, et seq. This act authorizes the multiple mineral development of the same tracts of land under both the mining laws and the mineral leasing laws. The act provides that leasing act operations, which are defined as operations conducted under a lease, permit, or license issued under the mineral leasing laws, "shall be conducted, so far as reasonably practicable, in a manner which will avoid damage to any known deposit" of any mineral subject to the operation of the mining laws.
>
> The act appears to recognize that leasing act operations can be conducted, if reasonably practicable, in a manner which might damage or destroy deposits of minerals within the mining laws. If this is a correct construction of the act, and even assuming that the recently located claims might be found valid, then the existence of the mining claims would not create any significant problems

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insofar as leasing act operations involving oil shale are concerned. It is questionable, however, that Congress intended, subject only to the condition that the operations be conducted in a reasonably practicable manner, to permit the damage or destruction of minerals within the mining laws by a leasing act operation without any consideration of the relative value of the minerals. It seems unlikely, for example, that Congress intended to permit a leasing act operation involving minerals having a present but relatively insignificant value to damage or destroy without recourse minerals having a very significant prospective value.

A study of the legislative history of the act might provide a satisfactory answer to the question of the intent of Congress. It seems more likely, however, that a definite answer will only be found as a result of litigation between conflicting interests asserting rights in leasing act minerals and minerals under the mining laws. Accordingly, any conflicting recently located mining claims will probably create some problems in the issuance of test leases.

The foregoing comments are, of course, a matter of initial impression. In view of the time restriction on your report, we have not had an opportunity to check the legislative history that might be available in the Denver Public Library. However, our Washington office has more accessible and better information available on the legislative history of the act and should be able to provide the committee with the results of a search of that material.

Palmer King

Palmer King
Regional Solicitor

cc:
Solicitor, Attn: Jon T. Brown,
Special Assistant